POWER

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THE KNOCKER

By RUFUS T. STROHM

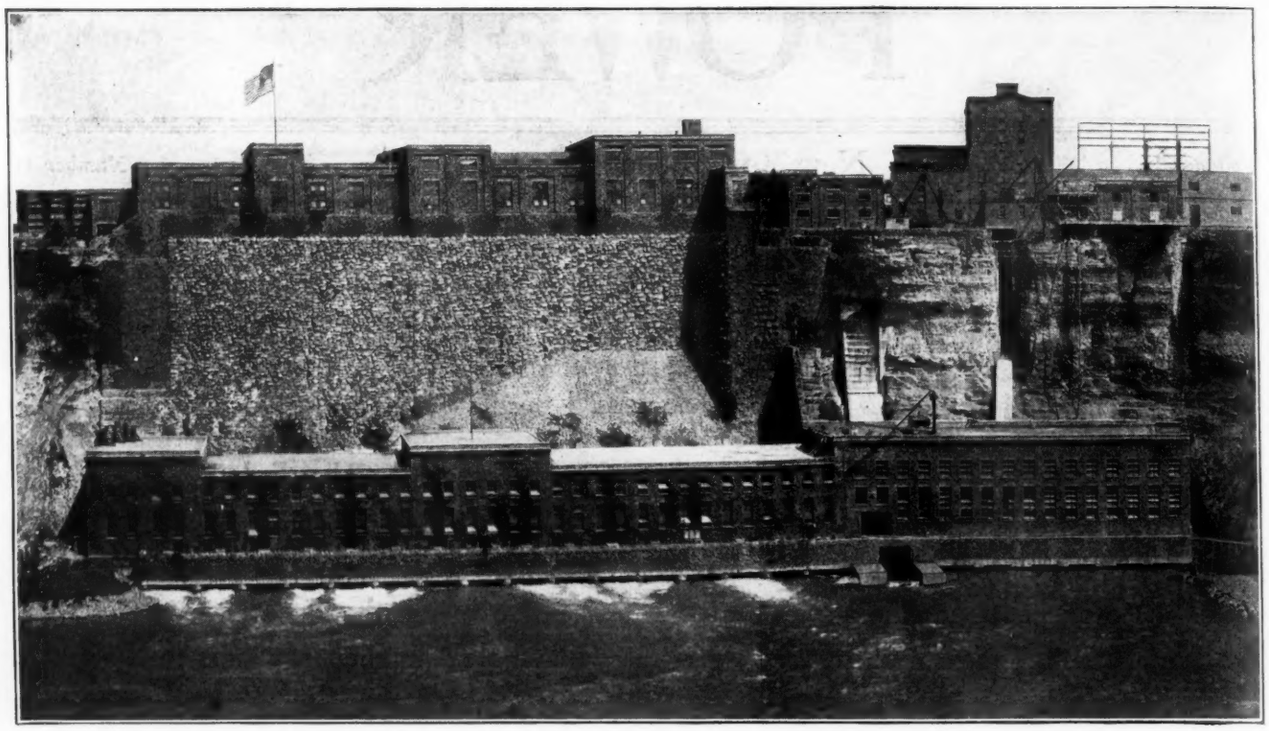
In every power house you'll find
The chap that wields the hammer;
He's everlastingly inclined
To discontent and clamor.
He knocks the men in places high,
He knocks the meek and lowly,
And while he knocks, his reddened eye
Emits a gleam unholy.

He loves to seize an honored name
And tear it into tatters,
Or desecrate some snowy fame
With nasty, muddy spatters.
He does his best to show the flaws
In every fellow-creature,
And thus ignores the moral laws
Delivered by the preacher.

The layout of the plant is bad,
According to his dictum;
The plant designer is a shad,
The owner is the victim;
The whole equipment is a mass
Of jumbled apparatus
That doesn't have a grain of class
Or engineering status.

He ridicules with caustic voice
The kind and make of stoker,
And looks upon the boiler choice
As worse than mediocre.
The type of turbine's wholly wrong,
He states to everybody,
And pipes and valves that should be strong
He vows are only shoddy.

Although he loves to swank and strut
Like some triumphant Pharaoh,
The truth is this—he's off his nut
And talks through his sombrero.
Such rant as his you're apt to meet
In any ten-cent shocker,
But still, it feeds his self-conceit,
And that's what charms the knocker.



World's Largest Hydro-Electric Units

Three 37,500-Hp. Hydro-Electric Units Installed by The Niagara Falls Power Company—Each One of These Units Has Carried Over 40,000-Hp. Load—More Than 90 Per Cent of the Total Energy in the Water Is Delivered at the Generator Terminals—Load on Thrust Bearings Approximately 500,000 Lb., with Only a 26-Hp. Friction Loss—Project Cost Approximately $8,000,000

By F. A. ANNETT
Associate Editor, *Power*

ELECTRICAL development at Niagara Falls began early and, like most of the early electrical undertakings, was a humble one as we see these projects today. In 1879 the first machine, a Brush arc dynamo, was installed to light Prospect Park at the Falls. This machine had a capacity equivalent to about 36 hp. From this 36-hp. machine the size of hydro-electric units has increased until, in the latter part of 1919, the largest hydro-electric generator in the world was put into successful operation — a machine having over one thousand times the capacity of the first unit, or 37,500 hp. Starting with this first electrical system, the size of electric-power projects has increased until today that of The Niagara Falls Power Co. has a total connected capacity of 498,000 hp. and hydro-electric development at Niagara Falls has expanded until at present there is a total connected capacity of over 850,000 hp. installed in the plants on the American and Canadian sides of the river, all driven from the same source —Niagara Falls. As a result of this phenomenal development industries have grown up, at and around the Falls, of such vital importance to this country and Canada that, if Niagara Falls was to fail for only a few weeks, our whole industrial structure would be seriously handicapped. The present hydro-electric power development is represented in seven plants, four on the American side and three on the Canadian, having an operating

The ultimate development of Niagara Falls will have a 300-foot head, when each cubic foot of water will produce an amount of power capable of lifting a 100-ton burden one inch from the tired shoulders of man.

Engineering thought blazes the trail to the most efficacious use of Niagara's waters. This thought now takes form in action, and action removes the doubt that theory could not solve. Results exceed the vision and now Niagara, more than ever, supplies the material wants of man. With equal vision, courage and skill must engineering control that part of the water which may be set aside for esthetic purposes. Engineering must shape its turbulence and so direct its cataract-forming currents that the maximum grandeur may obtain.

Engineering has made it possible to convert 90 per cent. of the stored energy of Niagara's water into useful forms of electrical power. Engineering can, and will, take but half the river's natural flow and raise its esthetic values to a level with the hydro-electric efficiency now obtaining. With half the water engineering will enhance the natural beauty and render a more sublime spectacle than nature, uncontrolled, now furnishes with all the water.—John Lyell Harper.

capacity of approximately 750,000 hp. These various plants are located as indicated on the map, Fig. 1, which also shows their capacities. Interconnected in one system are the four plants on the American side, with the plant of the Canadian Niagara Power Co. on the Canadian side, making a total operating capacity of 450,000 hp. In operation on this system are the machines that represent the earliest attempt to develop Niagara Falls power on a large scale and also the most recent. The initial installation in the first development consisted of three 5,500-hp. units, in plant No. 1 of The Niagara Falls Power Co., Fig. 1. The latest installation has three 37,500-hp. machines, in an extension to what used to be plant No. 3 of the Hydraulic Power Company of Niagara Falls. The first installation had a total capacity of 16,500 hp.; the latest has 112,500. In the headpiece, at the foot of the cliff, is shown plant No. 3 on the left extending about two-thirds of the way across the picture; on the right is extension No. 3. At the top of the cliff are located the offices, buildings of the company, the headworks buildings and control room, etc.

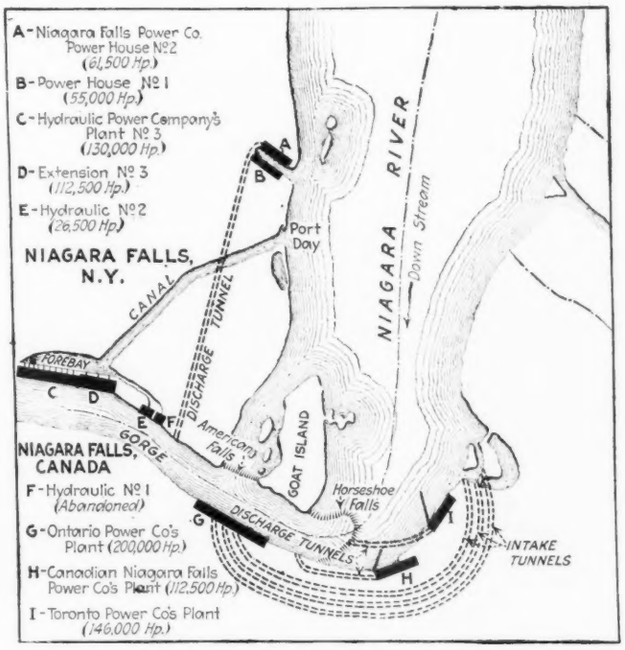


FIG. 1. MAP SHOWING GENERAL LOCATION OF POWER PLANTS AT NIAGARA FALLS

Power plants Nos. 1 and 2, Fig. 1, were the first installed by The Niagara Falls Power Co. and are on the river about one mile above the American Falls. At these plants the water is deflected into a forebay and passes through steel-plate penstocks, 7.5 ft. in diameter, to the turbines. As indicated in Fig. 3, the generators are located on an approximate level with the surface of the forebay and connect through a long shaft to the turbines placed near the bottom of the wheelpit. The water from the turbine is conducted through a tunnel, 7,481 ft. long, and discharged into the river about 2,000 ft. below the Falls. In these two plants the twenty-one turbines operate under an average effective head of 140 ft. and develop 10.8 hp. per cubic-foot second of water delivered to the turbine. Water for what used to be plant No. 3 of the Hydraulic Power Company of Niagara Falls, but is now plant No. 3 of The Niagara Falls Power Co., is carried through an open canal from the river, at Port Day, below plants Nos. 1 and 2, Fig. 1, to the top of the cliff about 4,400 ft. below the Falls. In 1852 the Porter family, whose estates consisted of a large farm

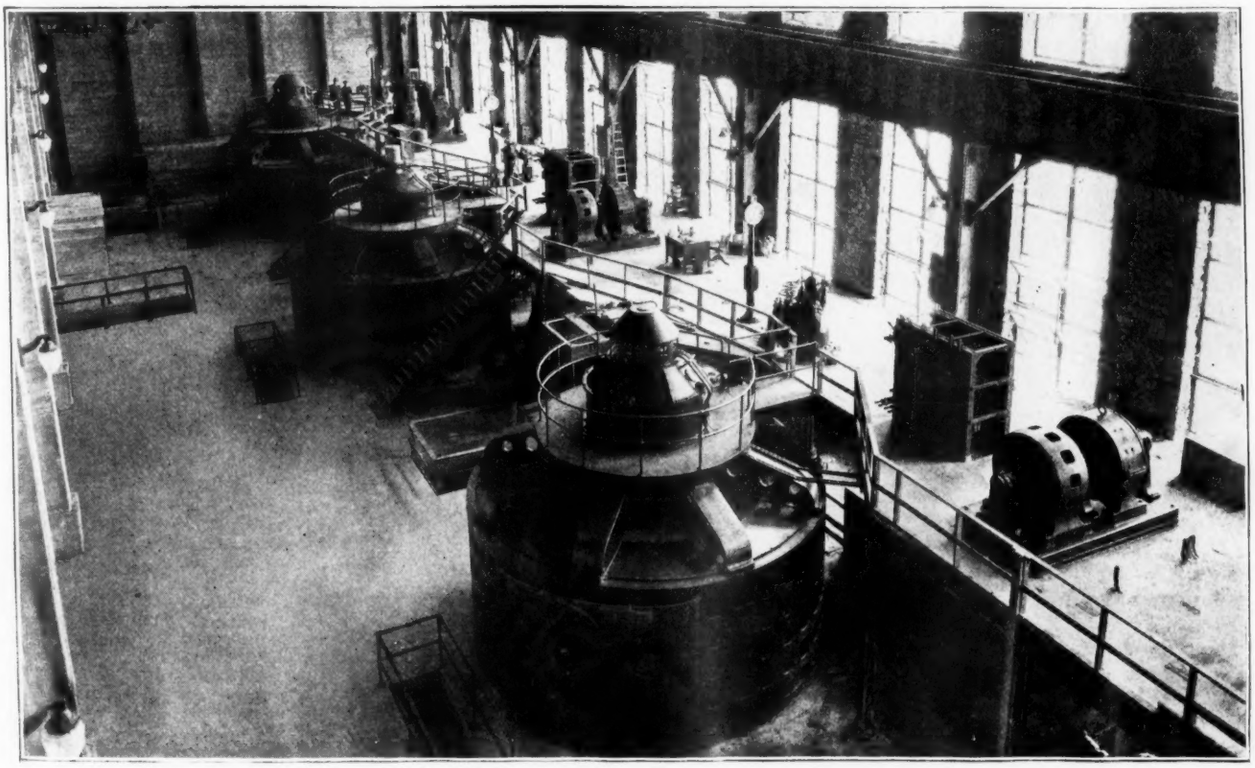


FIG. 2. INTERIOR OF GENERATOR ROOM AND OPERATING GALLERY OF NO. 3 EXTENSION

at Niagara Falls donated a strip of land 100 ft. wide for the construction of a canal, beginning at a point about one-half mile above the Falls and ending about 4,000 ft. below, which is the site of the present canal. The genius of foresight that dominated the Porters in making this grant is well demonstrated in the fact that the water carried in the canal on this site today develops over 200,000 hp. under the most efficient head of all schemes so far put into effect for generating power from the Falls. This canal was first built by Horace H. Day during the period from 1852 to 1860 and was 8 ft. deep and 35 ft. wide. But the first attempt to utilize the full head of water was not undertaken until 1895, when the Hydraulic Power Co. completed a plant of 6,850-hp. at the water's edge on the lower river. This plant, shown in Fig. 1 at *F*, is now abandoned. A second plant *E* was built by this company, of 26,500 hp. capacity, but it is now used as a reserve only. A third plant, *C*, of a total capacity of 130,000 hp. containing thirteen 10,000-hp. units, was installed between 1907 and 1913, and this constituted the maximum diversion of water that would be allowed until the power demands for manufacturing war materials created a very serious power shortage in the manufacturing district located around the Falls.

Confronted with this serious shortage of power and consequently a restriction in the production of war materials, the War Department requested all parties interested to submit plans for the development of the remaining water available for diversion, 4,400 cubic-feet seconds, allowed by the treaty with Great Britain.

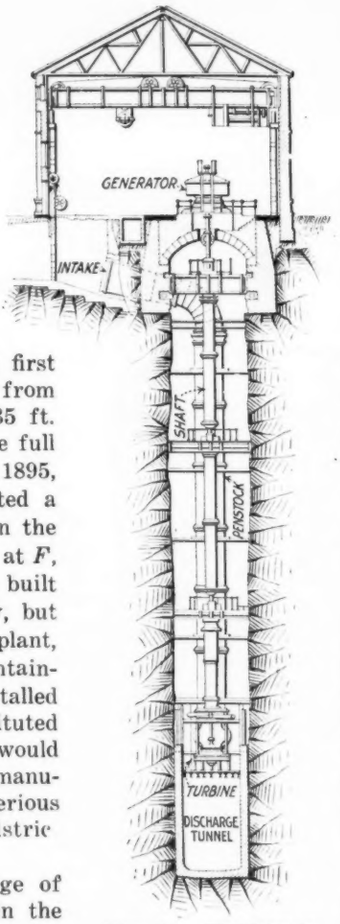


FIG. 3. SECTIONAL VIEW NO. 1 POWER HOUSE

As a result, the plan submitted by the, at that time, Hydraulic Power Company of Niagara Falls, was accepted as the one that would utilize the water most economically. The plan consisted of installing three 37,500-hp. units in an extension to be built to the Hydraulic Power Co.'s plant No. 3, and an enlargement of the canal that supplied this plant with water. To better utilize all the water at Niagara to which the various companies had property rights, it was suggested by the War Department that they consolidate into one company, as a result of which The Niagara Falls Power Co., Hydraulic Power Company of Niagara Falls and the Cliff Electrical Distributing Co. were consolidated under the name of The Niagara Falls Power Company.

In May, 1918, authority was granted by the War Department for carrying out the plan submitted by the Hydraulic Power Co. Nineteen months later, Dec. 20, 1919, the first unit was put into operation. If the progress of the work had not been slackened on account of the signing of the armistice, the first unit in this plant would have been ready for operation approximately twelve months after the work was started.

Ice had been giving considerable trouble and not infrequently restricted the capacity of the various power plants on the American side of the Falls. Therefore the successful operation of this new development required, among many other features, that an unobstructed flow of water be assured.

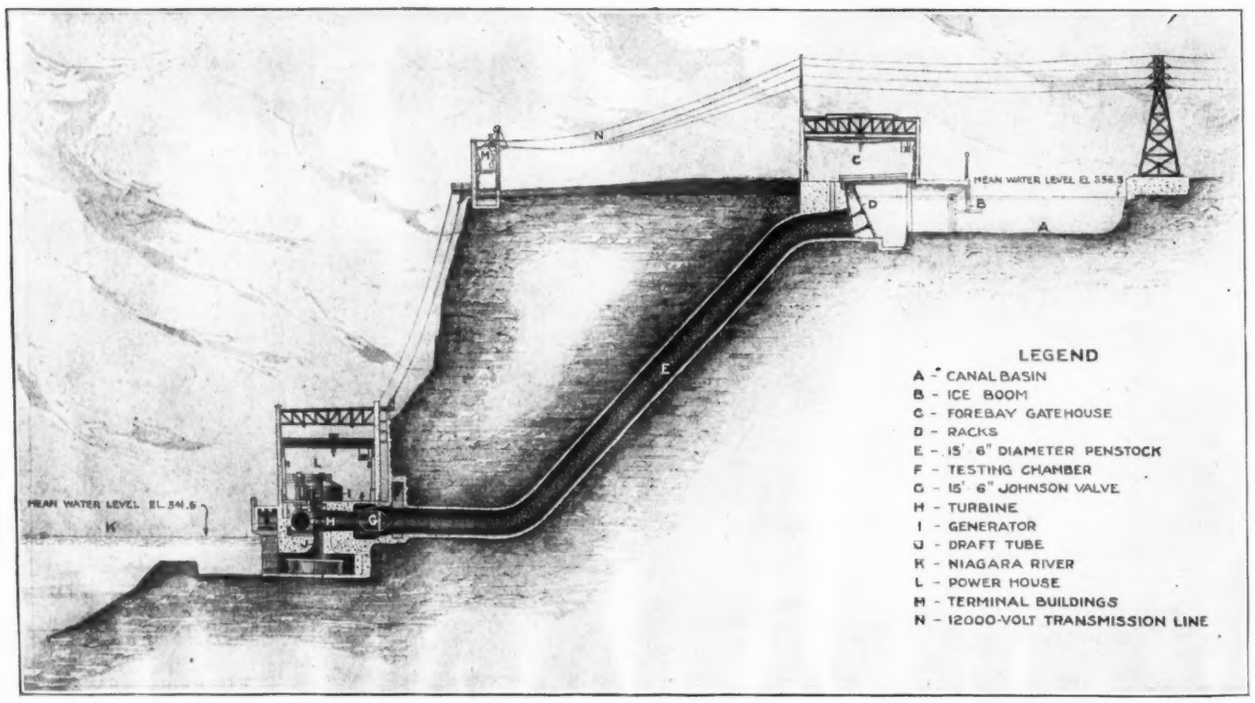


FIG. 4. SECTIONAL VIEW THROUGH POWER PLANT, ONE PENSTOCK AND FOREBAY OF NO. 3 EXTENSION

To accomplish this necessitated the cutting of a channel, 150 ft. wide, 20 ft. deep and over one-half mile long, curving from the intake at the canal at Port Day up the stream, in the bed of the river, which is solid rock. The object of this understream channel was to allow sufficient water to flow under the ice no matter how much the latter might pile up back of the ice booms. The canal, which was 100 ft. wide, was also deepened to 14 feet.

To supply the three new units with water from the present canal also required the construction of a new forebay 176 ft. long, 74 ft. wide by 28 ft. deep. All the work had to be done in a current that varies from one to six feet per second. Construction of the forebay necessitated the building of a cofferdam. This dam was built of Lackawanna sheet-steel piles on solid rock and so constructed as to allow pumping out the water back of it to a depth of 35 ft., and it is the only cofferdam that has ever been so constructed.

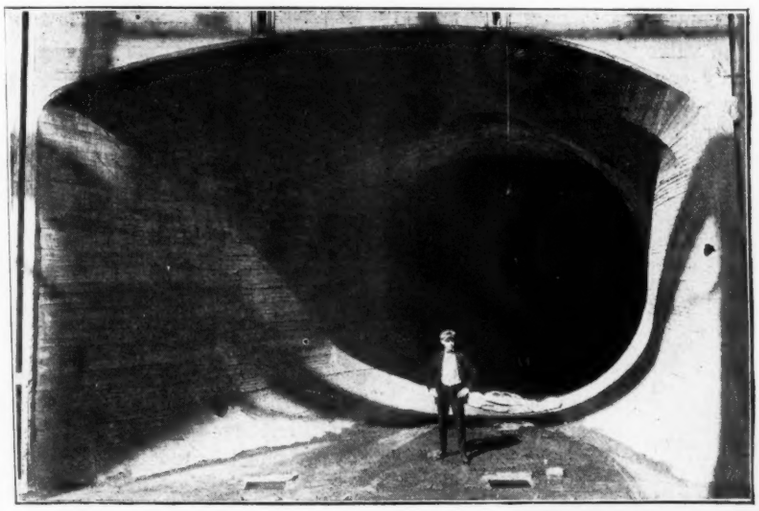


FIG. 5. BELL MOUTH OF ONE PENSTOCK

Ice apron *B*, Fig. 4, on the front of the forebay deflects the ice which continues down to the end of the canal, where a drag operated by two men and a 10-hp. motor takes it out and dumps it down over the cliff to the river below. If water was used to carry the ice away, sufficient to develop 500 to 600 hp. would be required, therefore the ice run is used only in exceptionally bad cases. It has not been necessary to use water to carry away the ice since the completion of the understream canal at Port Day. Last winter was the most severe winter in a decade, yet the ice that reached the forebay was successfully handled with the present equipment, therefore, it is doubtful if much water will ever again be required to handle it. Racks *D* are located in the forebay to catch any ice that may get by the apron. Very little débris comes down in the water, consequently no trouble is experienced from this source. Since the bottom and sides of the canal as well as the river bottom are solid rock, no difficulties are experienced with sand.

The entrance to the three penstocks, for No. 3 extension, from the forebay are bell mouths, Fig. 5, 28 ft. wide by 20 ft. high and gradually taper down to a true circle 15.5 ft. in diameter. From the bell mouth the penstocks curve to an angle of 45 deg. and extend down to a level with the wheels (see Fig. 4) where they make another easy curve and extend out 90 ft. to the face of the cliff. These penstocks are 350 ft. long, cut in solid rock, and are lined with concrete throughout their entire length. The horizontal section, in addition to having a concrete lining, is also lined with 1¼-in. boiler plate, which acts as an anchor for the turbine casings to the penstocks. The general arrangement is clearly indicated in the sectional view, Fig. 4.

Steel-plate gates are located in the intake to the penstocks. These gates are handled by cranes and slide down on racks placed about 30 deg. to the vertical. In each gate is a trap to bypass water and fill the penstocks before the gates can be opened. This trap is open during the closing of these gates, so that the pressure of the water will not prevent the gates from seating.

Each of the three turbine casings is connected to its penstock through a valve, *G*, Fig. 4, hydraulically operated and electrically controlled. These valves, which are the largest in the world, were furnished by the Larner-Johnson Valve and Engineering Co. Fig. 7 shows one of them with the penstock end of the casing removed. The control gear is clearly indicated on the side of the valve. The outer valve housing is of cast steel and steel plate and is 17 ft. inside diameter through the body of the valve and tapers to 10 ft. 6 in. diameter at the outlet end. The entrance end to the valve housing is made of steel plate forming a flaring extension of the 15-ft. 6-in. penstock. Throughout the total length of the valve, approximately 24 ft., the area of the water passage is reduced without abrupt changes or sharp curves, and the stream-line shape of the valve parts renders the hydraulic losses practically negligible.

FIG. 6. TAILRACE END OF DISCHARGE, SHOWING CONCRETE PIERS SUPPORTING TURBINE FOUNDATIONS

The valves are of the balanced needle type, having a movable plunger sliding in an internal cylinder

(see Fig. 8). An internal cylinder *C* is supported from the valve housing, and the movable plunger *P* is arranged so that it works within cylinder *C*. When the valve is open, as in the figure, hydraulic pressure from the penstock is applied not only to the outside of the plunger, but also to the inside of chambers *A* and *B*. This creates a state of hydrostatic equilibrium in all parts of the plunger. To close the valve, pressure in chamber *B* is reduced by discharging water from it into the tailrace and allowing the pressure to be applied in chamber *A*. This pushes plunger *P* forward until it seats at *S*. During the opening operation chamber *A* is allowed to discharge into the tailrace and pressure from the penstock is applied within chamber *B*. Operation of the plunger is accomplished entirely by the hydraulic pressure in the penstock, no external force or pressure being required. The mechanism that controls the movement of the needle plunger is shown in place on the side of the housing, Fig. 7. The valve may be manually controlled locally, or electrically controlled from a switch station on a pedestal (shown back of the governors in Figs. 18 and 21), near the generating

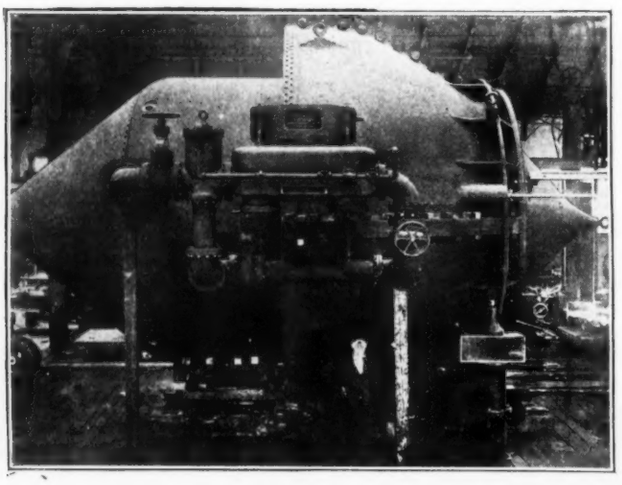


FIG. 7. JOHNSON VALVE WITH CONTROL GEAR

units. A solenoid actuates a pilot valve, and the pilot valve controls a relay valve which regulates the flow of water to and from the main valve for its operation. The valve does not operate with change of load on the turbine, all the fluctuations being taken care of by the governor operating twenty radial vanes that control the amount of water reaching the runner. As shown in Figs. 18 and 21, indicators with illuminated dials mounted on top of the pedestals that the Johnson valves are controlled from show the position of the turbine gates.

The rate of the valve stroke may be regulated to suit the conditions and may be set for any time up to a minimum of 30 sec. for a complete stroke in either direction. The valve is so designed that it will close automatically in case of a serious break in the wheel casing.

Exclusive of the steel-plate housing at the upstream end, the complete valve weighs approximately 200,000 lb., and the plunger or moving element, 52,000 lb. The force required to move the plunger is extremely small, as no sliding surfaces are subjected to a difference of hydraulic pressure and only the friction of the plunger moving in the internal cylinder must be overcome. To unseat the plunger and fill the wheel casing, a force of 520,000 lb. is available, and to complete the opening stroke the available force is 2,000,000 lb. To close the plunger in dead water, the available force is 415,000 lb., and this is greater in moving water. A force of 1,560,000 lb. is applied on the plunger to hold it against

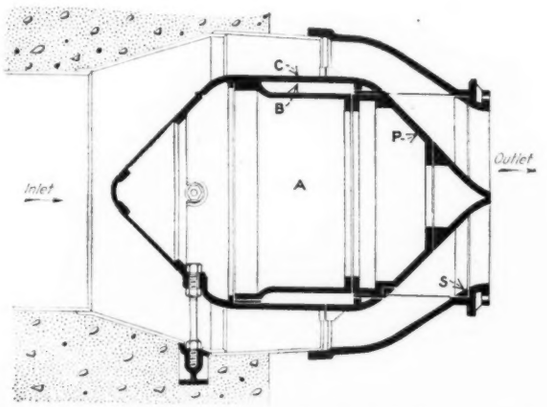


FIG. 8. SCHEMATIC DIAGRAM OF JOHNSON VALVE

its seat. In spite of the enormous size of the valve and forces for operation, the operator has absolute control of the stroke at all times and may stop the plunger immediately at any intermediate point.

No provision was necessary to take care of the surges in the penstock, for being hewn through solid rock the penstock itself provides sufficient strength to withstand any force that may be set up, due to suddenly shutting down a machine.

In the design and building of the units four manufacturing companies are represented. One complete

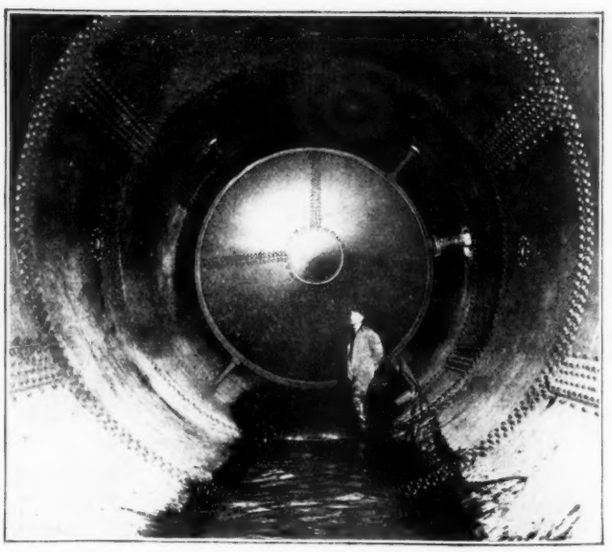
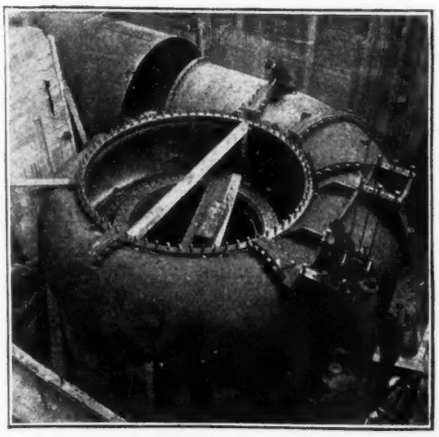


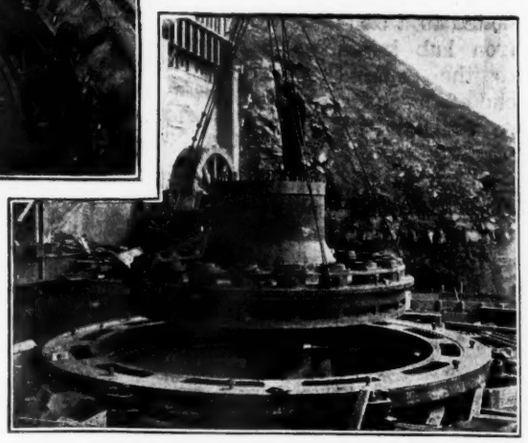
FIG. 9. JOHNSON VALVE INSIDE OF PENSTOCK

unit—generator and turbine—was designed and built by the Allis-Chalmers Manufacturing Co., one generator each by the General Electric Co. and the Westinghouse Electric and Manufacturing Co., and the turbines for these two generators by the I. P. Morris Co. Each turbine is of the vertical shaft, single-runner, Francis

type, operating under a head of 215 ft. at a speed of 150 r.p.m. and is rated at 37,500 hp., although each has already carried more than 40,000 hp. load. The three units were designed to develop an average working load of 100,000 hp. This load is being carried continuously and with ease. Taking all frictional and other losses, from forebay to switchboard, into consideration, these units are securing 90 per cent of the potential energy in the water used.

Each complete unit—generator, turbine and casing—weighs approximately 1,000 tons and is set on a reinforced-concrete slab, 11 ft. thick, 53 ft. wide and 55 ft. long, resting on reinforced-concrete piers, Fig. 6; 46 tons of steel reinforcing was used in each slab. The casings of the I. P. Morris turbines are of cast iron made in six sections and are embedded in the concrete substructure of the power house. As can be seen from Fig. 10, this casing is bolted together by flanges on the outside, consequently the inside is smooth, and is designed for a gradual acceleration of the water as it passes around the volute. The intake is 10 ft. 6 in. in diameter, and the total weight of the casing is about 263,000 lb. A cast-steel speed ring, weighing 85 tons, cast in three pieces and bolted together, is provided to stay the casing and transmit the weight of generator and floor to the foundations. Cast-steel guide vanes with polished surfaces are used, and the lubrication of all guide-vane bearings is effected by means of a central grease gun. The guide vanes may be clearly seen in Fig. 11. With the grease gun it is possible to supply any bearing on any guide vane with a definite amount of lubricant. The runner is of cast iron, in one piece, having a maximum diameter of 10 ft. 6 in. and a total weight of 27,000 lb., and the weight supported by the thrust bearing is about 500,000 lb. The shaft is 25 in. in diameter and is provided with a lignum-vitæ guide bearing at the turbine and a babbitted guide bearing on top of the generator.





FIGS. 10 TO 12. ASSEMBLING ONE OF THE TURBINES

Fig. 10 (upper left)—Assembling cast-iron sections of turbine casing. Fig. 11 (center)—Guide vanes and turbine runner in place; tops of guide vanes are clearly shown around the outside of the runner. Fig. 12 (lower right)—Cover plate of turbine being lowered into place.

The draft tube is of the Moody spreading type and is of special value in that it regains the whirl component as well as the axial component of the velocity of the water leaving the runner. This results in higher efficiency than the old type of curved draft tube, which does not regain the whirl. The spreading tube also eliminates surging and water hammer, which so often occurs with curved draft tubes. These draft tubes are shown in section in Figs. 13 and 14.

A renewable ring is provided in the draft tube just below the runner, and the upper section of the draft tube is furnished with manholes for the inspection of tube and runner discharge. The total weight of each turbine is about 765,000 lb., and the installation throughout is notable for its heavy construction.

Governors of the I. P. Morris double floating-lever type are used to regulate each of the two turbines. The actuator, Fig. 18, is located on the switchboard gallery with the gate-opening indicator and control stand, and the regulating-valve stand is on the main generator floor and is provided with plunger valves of the Johnson type. Hand control is arranged for with similar valves, and all are operated by a lever on the control stand. By this means the operation of changing the unit from hand to governor control is easily effected, all valves operating simultaneously. This arrangement is foolproof and obviates the danger of operating the valves in the wrong order.

On the Allis-Chalmers turbine the casing, Fig. 22, is made up of a number of conical steel plate sections riveted together; consequently, there are both girth and longitudinal seams. All rivets are countersunk on the inside of the casing. Where the penstock connects to the Larner-Johnson valve on the forebay end, it is 15 ft. 6 in. in diameter, and tapers down to 10 ft. 6 in. on the turbine end, at which diameter it connects to the turbine casing. As can be seen from Fig. 15, a straight connection is used from the Johnson valve to the casing on the two units to the left where the connection of the machine to the right increases from a diameter of 10 ft. 6 in. at the valve to 11 ft. 6 in. at the entrance to the spiral. The plates are $\frac{7}{8}$ in. thick at the entrance to the casing and $\frac{1}{2}$ in. thick at the small end of the volute. The casing is riveted to a cast-steel speed

ring, weighing 85,000 lb. Twenty cast-steel guide vanes control the water from the casing to the runner. These vanes are connected to the shifting ring through adjustable links so proportioned that they will fail before a guide vane or its shaft is injured if any obstruction should lodge between vanes. The runner is of cast-iron bolted to a cast-iron hub keyed to the tapered end of the shaft, as indicated in Fig. 20. A lignum-vitæ guide bearing, Fig. 19, is mounted directly above the turbine, the lignum-vitæ being set with its end grain toward the shaft, and is lubricated with water from the headrace supplied through a fine strainer. Lubrication of the guide-vane bearings is accomplished by using a pressure grease cup on each bearing.

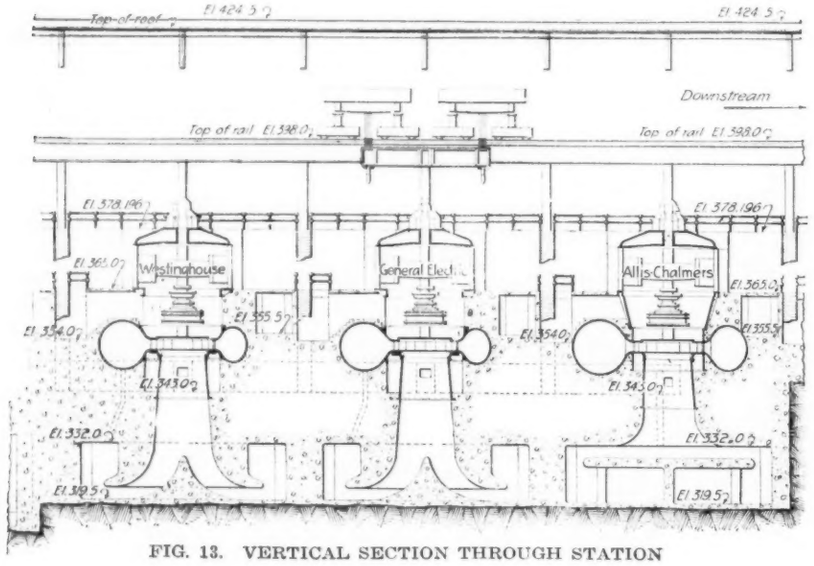


FIG. 13. VERTICAL SECTION THROUGH STATION

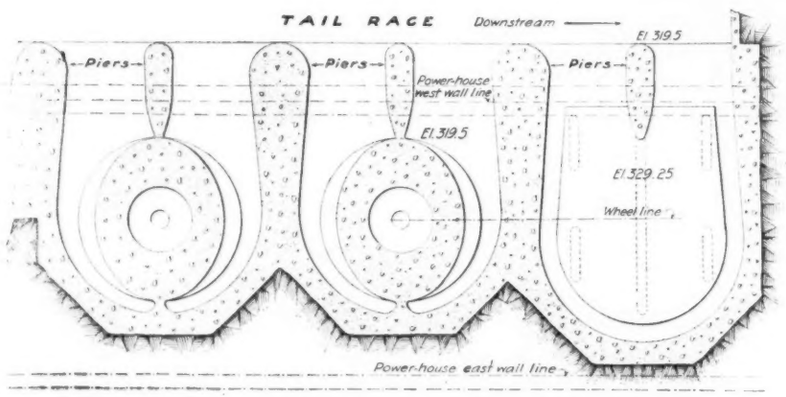


FIG. 14. HORIZONTAL SECTION THROUGH DRAFT TUBES

The turbine discharges into a single draft tube of the White hydraucone regainer type. Reference to Figs. 13, 14 and 20 will make the construction clear. In the hydraucone regainer, a straight bell-mouth tube is used; mounted directly below the mouth of this tube is a concrete slab supported on piers. The discharge toward the river goes directly to the tailrace, and the discharge toward the penstock drops down and goes under the concrete slab to the river. In the divided draft tube, instead of the discharge being out under a concrete slab, after it leaves the draft tube the flow is upward and around the lower end of the draft tube. The chief result accomplished is, the water does not turn on itself, either axially or radially until it discharges; thus a large percentage of the velocity energy in the discharge is regained. By the use of the hydraucone or spreading draft tube about 80 per cent of the velocity head in the discharge is recovered, whereas with the old type of curved draft tube a large proportion of this velocity head is always lost. Apparently, one device is as efficient as the other. Tests show that over 90 per cent of the total energy in the water is delivered at the generator terminals and the turbines themselves have an efficiency of 93 per cent.

The effectiveness of the hydraucone regainer and divided draft tube is illustrated in the headpiece. On the right it is seen that the tailwater from extension No. 3 is practically smooth, while from plant No. 3, on the left, the discharge gives evidence, by the whiteness of its surface, of considerable velocity. By looking at the discharge of No. 3 extension with all three machines operating under normal full load, it never would be suspected by the current that it represented a flow of some 4,500 cubic-foot seconds. In this machine the governor flyballs are mounted directly on the turbine shaft and are connected to the governor mechanism through rods and bell cranks, as indicated in Fig.

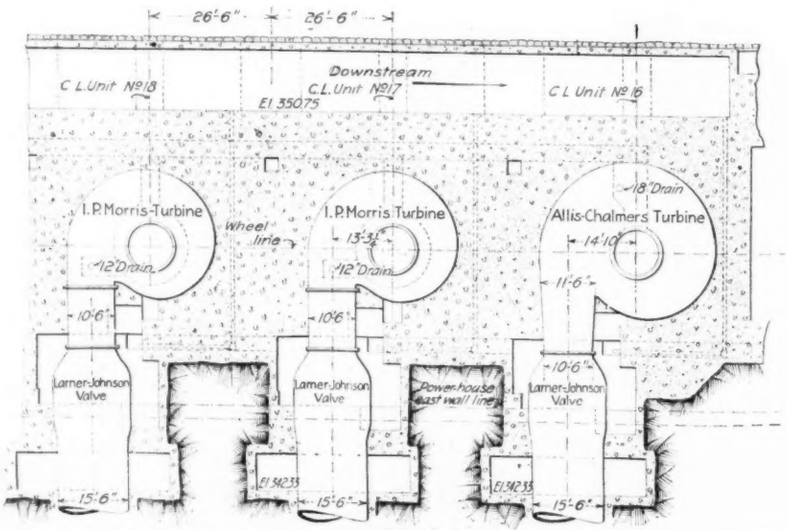


FIG. 15. HORIZONTAL SECTION THROUGH STATION, SHOWING PENSTOCK VALVES AND TURBINE CASINGS

20. In the governor stand, Fig. 21, are three piston valves—the pilot valve, intermediate valve and main valve. The motion of the flyballs operates the ⅜-in. pilot valve, which in turn operates a 3½-in. four-ported intermediate valve, and the motion of the latter varies the pressure on either end of the four-ported main valve, which is 12 in. in diameter. A motion of only one-half inch of this main valve is all that is required to pass sufficient fluid to cause the operating pistons to move from one end of their cylinders to the other in two seconds. As is clearly indicated in Fig. 20, the fluid pipes, which are 6 in. in diameter, from the governor stand connect to the operating cylinders outside the pit liner. These operating cylinders are so located as to allow removing the turbine cover plate without distributing the governor piping on cylinders. Fluid use in the governors is about 99 per cent water and 1 per cent oil, supplied from a central pressure system. Three governor fluid pumps of the centrifugal type are provided. Two of the pumps are driven by 75-hp. induction motors and the third by a direct-current motor. One of the alternating-current motors is started from a manually operated starter on the operating galley. The other alternating-current motor is equipped to start automatically by a float switch in the sump tank. The direct-current motor is also arranged to start automatically from a float switch adjusted to follow the alternating-current motor-driven pump. This arrangement makes it practically impossible for the governor-fluid supply to fail. Pressure of 115 for operating the governors is obtained by static tanks at the top of the cliff. Should for any reason the fluid supply to the governors fail, which, as previously stated, is practically impossible, they may be operated with water taken from the penstocks. The governors on all machines will close the gates from full opening in three seconds. In case of an interruption of the load on any one of the units or an interruption of the exciter circuit, the governors will completely close the gates and shut the machine down. Each of the three generators is designed for a capacity of 32,500 kva. and generates 12,000-volt three-phase 25-cycle current when operating at 150 r.p.m. Although designed and built by different companies, each machine has about the same external appearance, and to this end the manufacturers co-operated, so that the installation presents a uniform appearance, Fig. 2. The weight of the Allis-Chalmers generator is supported by a cast-iron pit liner, which in turn rests upon the turbine casing and speed ring, thus making the generator and turbine one composite unit, Figs. 13 and 20. This pit liner is also shown in Fig. 22, located within the spiral casing. A cast-iron ring grouted into the bulding structure and supported from the turbine casing and speed ring is used as a foundation for the other two generators, Fig. 17. A comparison of these details can be seen in Fig. 13.

FIG. 16. GENERATOR FIELD COIL

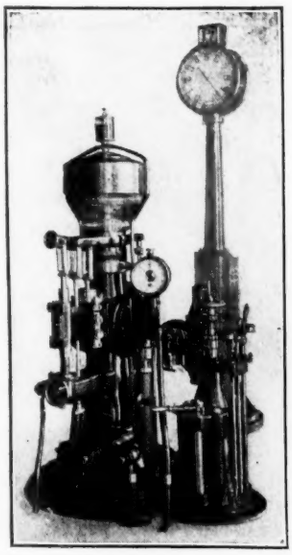


FIG. 18. I. P. MORRIS GOVERNOR AND ACTUATOR AND GATE-OPENING INDICATOR

As to the internal construction of the generators the engineers of the manufacturing companies were left at liberty to follow their own ideas regarding details, the main restriction being that the electrical characteristics of the three machines must be such that they would operate satisfactorily in parallel. A box frame of usual design, 21 ft. outside diameter, cast in four sections, is used for the stator. On account of the larger size of the units the stator cores were stacked and the machines wound when they were installed. Both ends of each phase winding are brought out so that a balance system of relay protection can be used. The windings are connected in star and the neutral grounded through a resistance of approximately 5 ohms, obtained by using a water rhoestat. One of the distinguishing

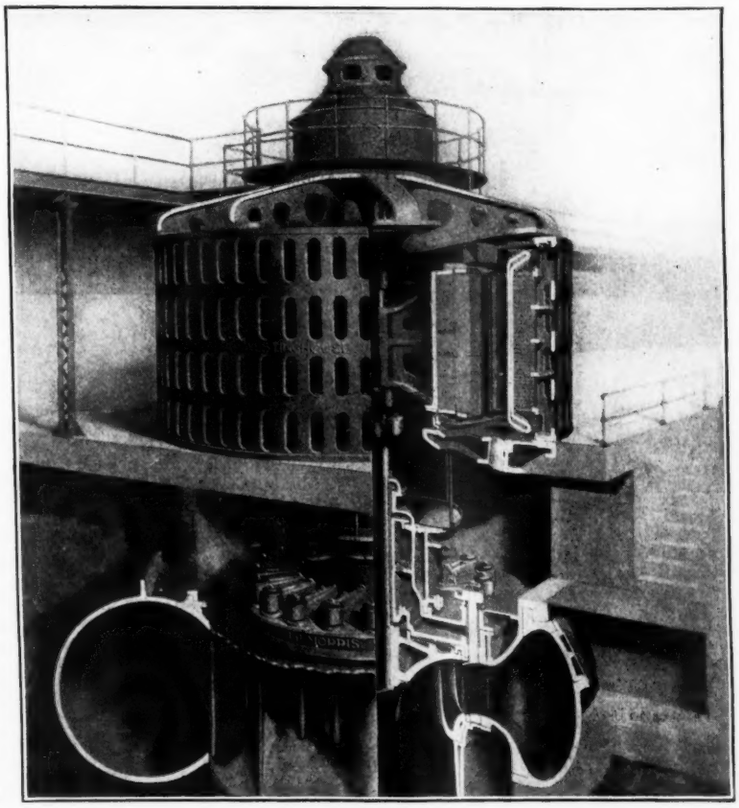


FIG. 17. SECTIONAL VIEW THROUGH UNIT ON LEFT IN FIG. 13.

features in the internal construction of the machine is found in the rotor. In the Allis-Chalmers machine the rotor consists of two cast-steel field rings, machined on all surfaces and shrunk onto a cast-steel spider. The field poles are made in two sections, each section being dovetailed to the field ring. In the General Electric machine, the spider consists of six cast-steel wheels, with spaces between them for the circulation of air. These wheels are rabbeted together at the hubs and held together by bolts through the arms of the spider. The polepieces are in one section and held to the rotor by two dovetails. A ring built up of ⅛-in. laminations on a cast-steel spider is the rotor construction used in the Westinghouse machine. One-section polepieces held to the rotor with a single dovetail are used. An idea of the size of the generators is given in Fig. 16, which shows a man standing alongside of a field coil.

FIG. 19. TURBINE-GUIDE BEARING, UNIT FIG. 20

The shafts are 27 in. in diameter below the rotor and are fitted with a 45-in. forged-on steel flange, for bolting to a corresponding flange of the turbine shaft. On the upper end of the shaft is the Kingsbury thrust bearing, carried on a bridge having eight radial arms. This bridge is of cast-steel in two parts. Each bearing is 49 in. outside diameter and capable of carrying a suspended load of approximately 500,000 lb., which is ample to carry the weight of the rotating element and downward thrust of the water. A total downward load of approximately 470,000 lb. is caried on the thrust bearing, 100,000 lb. of which is due to the water thrust on the turbine runner. Directly under the thrust bearing is the upper guide bearing, which is 26 in. in diameter and 36 in. in length. The thrust bearing runs in a bath of oil supplied from a central system. No oil-cooling coils are provided in the thrust-bearing housing, the oil being cooled and filtered in the central system.

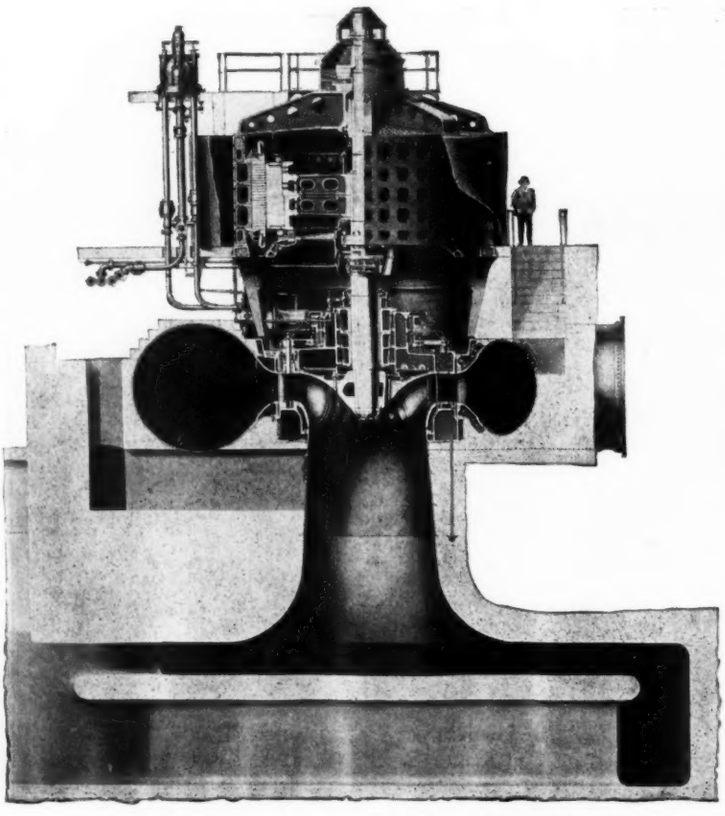


FIG. 20. SECTIONAL VIEW THROUGH UNIT NO. 16

Special care has been taken in the design of the oiling system to make it as simple as possible. Oil from the central system, after passing through a duplex strainer,

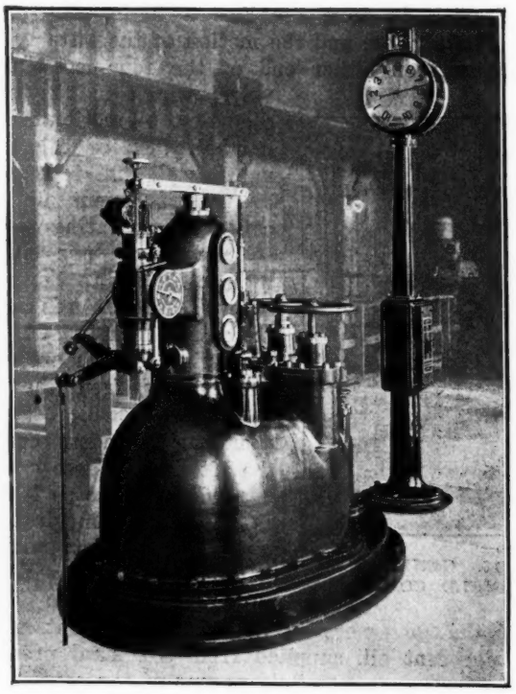


FIG. 21. ALLIS-CHALMERS GOVERNOR STAND AND GATE-OPENING INDICATOR

flows into two feed pipes, one leading to the thrust bearing and one to the guide bearings. Each of the pipes is provided with sight-flow indicators and regulating valves. An oil meter is installed in the thrust-bearing feed line, and the circulation of the oil is regulated to about 35 gal. per min. As previously stated, the load on the thrust bearings is approximately 470,000 lb., nevertheless the friction loss in the bearings is only about 26 hp. The machines from standstill will begin revolving on one per cent gate opening. To bring the rotating element to rest after the gates have been closed, and also to prevent the rotor from turning in case of leaks through the gates, brakes are installed on the generators. These brakes are operated by compressed air, from a cock mounted near the hand-control stand located near the gover-

nor, and are capable of bringing the generator to rest from full speed, in four minutes. Ventilating air for the generators is taken into the top of the machine from the generator room and also from the pit under the machine. The amount of air required by the different machines to carry off the heat varies from 70,000 to 90,000 cu.ft. per min. This air is forced over the windings and through the ventilating ducts in the cores by steel-plate centrifugal fans mounted on the ends of the rotor. The field poles and ventilating openings in the rotor rims also set up a strong blowing action. At present the air discharges through the stator yoke into the generator room. Provisions have been made to surround each generator with a steel-plate housing as indicated in Fig. 20. This housing will be connected to a duct system, so that the ventilating air can be disposed of in several ways, by auxiliary fans, one for each generator. In the summer months the ventilating air can be discharged outside the station. In the winter months part of it will discharge into the station and control room for heating, and the remainder will go to the ice runs. Of interest is the large crane, one end of which is shown in Fig. 23, at the top of the cliff for handling all materials for the plant at the lower river's edge. This crane is capable of lifting a modern freight car and its load off the track, carrying it in over the edge of the cliff and lowering it down to the plant below. The figure shows the crane raising an empty flat car after it has been unloaded in the plant.

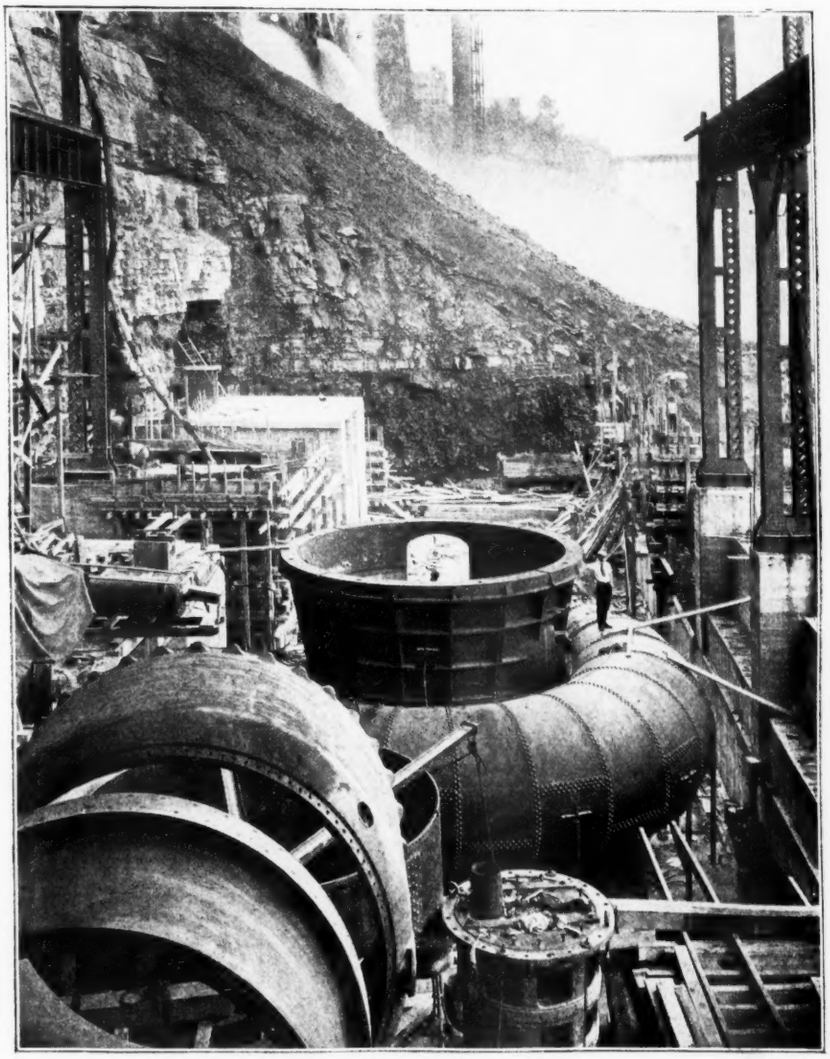


FIG. 22. INSTALLATION OF UNIT NO. 16 TURBINE CASING AND PIT LINES IN PLACE

One of the unique features of the station is the simplicity of the control. The leads from the generators go to an oil switch and then directly to a six-circuit transmission line carried on steel towers that run to the Echota substation, three miles away. This transmission line is designed to have, eventually, a capacity of 400,000 kw. All circuits are carried on the same towers. Most of the towers are built on concrete foundations, but a number of them have foundations built on the cantilever principle and extend out over the canal. From station No. 3 power is transmitted by underground cable, but when duct capacity for the new development was considered, which it is expected will eventually reach 400,000 kw., it was found practically impossible to obtain this on account of street limitations, therefore overhead transmission was adopted. The generator oil switches are automatically tripped by inverse-time-limit relays, set for 3 sec., when overloads occur outside the generators. In case of trouble within these generators the switches are opened instantaneously and the field circuit is killed by a balanced relay system of protection operated from current transformers in the generator leads differentially connected. To give this system of protection maximum reliability, the relays are placed near the generators. This avoids the long leads that would be required if these relays were in the control room at the top of the cliff, and the wiring of this system is also made independent of all other circuits. Two current transformers and two inverse-time-limit relays, both connected open delta, protect each generator from overloads. The neutrals of both the current transformers and relays are grounded. In the ground connection of the transformers is connected a relay, which trips the generator switch when the current to ground reaches approximately full-load value. The inverse-time-limit relays are rated at 5-ampere where the ground relay is only 2.5-ampere capacity.

At the top of the cliff above the main generator station is the control room. On account of the simplicity of the switching arrangement the control is greatly simplified, as is clearly indicated in Fig. 24. When a

switch is opened, an annunciator on the control board shows the relay that operates it, thus indicating the source of the trouble. In each of two of the generators are 18 temperature coils; the third machine has 18 thermocouples located at different parts of the stator windings. Six of these in each machine, that show the

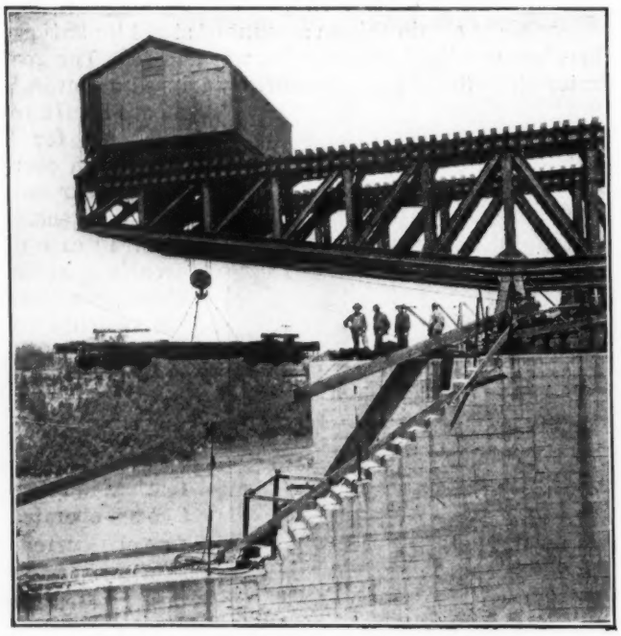


FIG. 23. LARGE CRANE AT TOP OF CLIFF

highest temperatures, are connected up to an indicator in the control room.

Excitation for the alternators is obtained from 2,200-volt induction-motor, direct-current generator sets. Each exciter is of 225-kw. capacity, shunt wound with interpoles, and generates 220 volts. The induction motors can be supplied from three sources: Transforming the 12,000-volt current from the main generators down to 2,200-volts; 2,200-volt current from No. 3 station, and also from a 2,200-volt substation in No. 3 gatehouse. Any one of these three sources can be connected to a duplicate set of busses, and the 2,200-volt induction motor, driving the exciters, connected to these busses through selector oil switches. An emergency source of excitation may be obtained from No. 3 station's direct-current busbars. This circuit is connected through a field rheostat located near the main units and connected to a busbar. To this busbar the field coils of any one of the alternators may be connected in case of failure of its motor-generator exciter. Although all three machines are connected to the emergency excitation source, the switches are so interlocked that only the field coils of one machine can be connected to this circuit at one time.

In laying out the station effort was made to divide the electrical and mechanical operating functions. Electrical operation is centered in the control room and the mechanical in the station. How well the designing engineers have succeeded in their efforts to simplify operation is evidenced by the fact that a station of a normal operating capacity of 100,000 kw. is being operated by three men on a shift, or a total of nine men on the three shifts. One man is located in the control room and two in the station. Although these units are the largest in the world, no failure of any part of the equipment has been experienced since the machines were put in service. This is very remarkable since the design and construction of the plant represents a distinct forward step in hydro-electric development. In carrying out this project, it was necessary for the engineering staff to make the plans as the work progressed. Nevertheless, less than $1,000 was expended in changing plans. This, it must be admitted, is a remarkable record in engineering work involving an expenditure of approximately $8,000,000. The project, although carried out by Government sanction for war work, was financed entirely by The Niagara Falls Power Co. Exhaustive

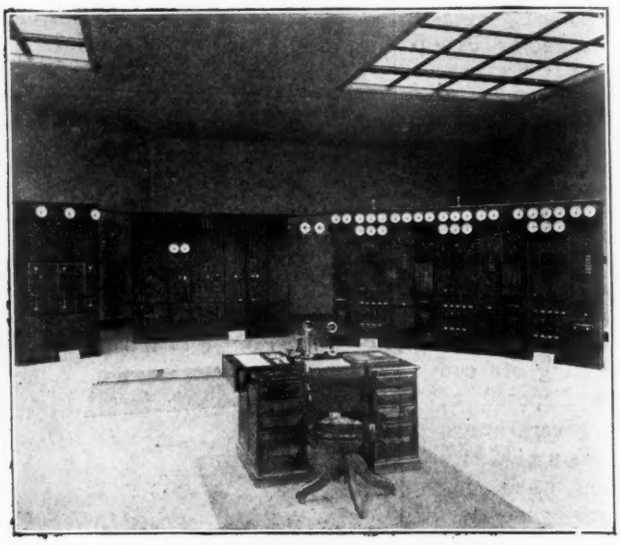


FIG. 24. MAIN SWITCHBOARD IN CONTROL ROOM

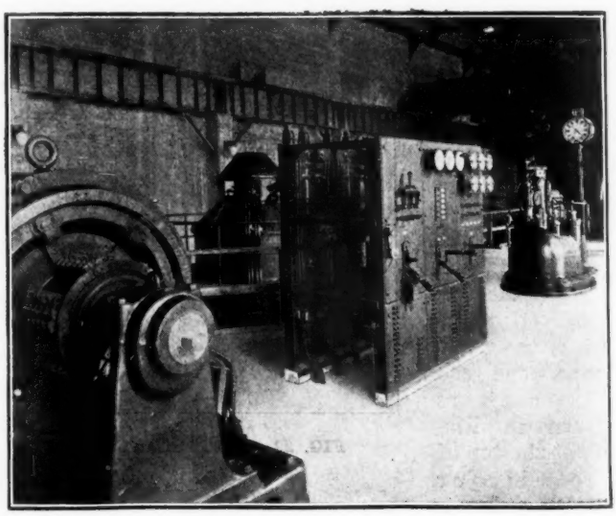
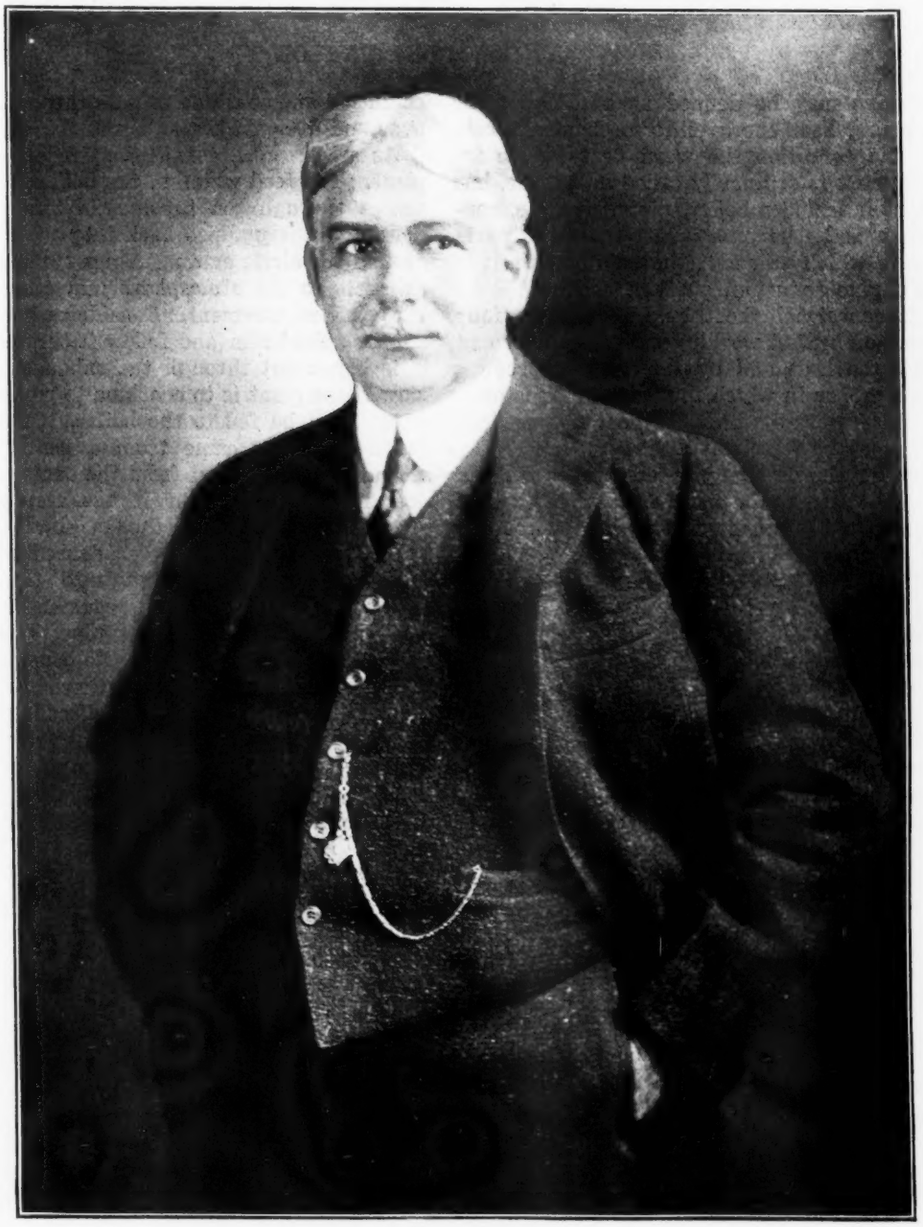


FIG. 25. VIEW OF OPERATING GALLERY IN MAIN STATION
Motor generator exciter in foreground, control switchboard for auxiliary electrical equipment in center, governor stand and gate-opening indicator on the right for unit No. 16.

tests are being made on these units, the results of which will be available for publication at a future date.

The author of this article wishes to acknowledge the assistance and co-operation rendered, in the preparation of this story, by John L. Harper, vice president and chief engineer of The Niagara Falls Power Co., and his engineering staff, also by engineers of the companies supplying the hydraulic and electrical machinery.



John Lyell Harper

Chief Engineer and Vice President, The Niagara Falls Power Company

Two billion, thirty-four million kilowatt-hours output and eighty-four per cent load factor is the 1919 record of the Niagara Falls Power Company, which claims John Lyell Harper as its chief engineer and vice president. He never bosses his "boys." Yet all the engineering science, art and skill that so freely abound in this great organization pay tribute to his kindly, friendly direction and control.

That Niagara leads America in electrical output and load factor is due largely to the genius of this man, whose closest associates are never sure whether his seriousness is facetious, or his facetiousness is serious.

During the war, when there was a serious shortage of power at Niagara Falls and the War Department requested plans for the most economical development to utilize the remaining water available for diversion, it was the Hydraulic Power Company, of which Mr. Harper was chief engineer, that supplied the plan. Again, when all the power companies on the American side of the Falls were consolidated into The Niagara Falls Power Company, it was John L. Harper who was chosen chief engineer and vice president of this great organization. Mr. Harper's plan for the future development of Niagara Falls, whereby 60 per cent of the total flow of the river may be used for power development and the remaining 40 per cent so utilized as to give the Falls an esthetic value equal to or even greater than the present spectacle, has made this man a national figure.

Like all such men, he loves the soil. By vocation an engineer, he is a farmer by avocation. And so he supports a fruit farm, bordering the lower Niagara River, and peopled by little Harpers. His love of harmony is nicely exemplified by the color scheme that obtains on the farm. *Any* color is a good color, provided it is *buff!* From sleek Jerseys to rooting porkers, from Airedale dog to downy ducklings, buff is the color.

The Limitations of Efficiency in a Steam Engine

Why It Is Necessary To Throw Away Part of the Heat Supplied to It

By DeWITT M. TAYLOR

A HEAT engine may be defined as a machine for transforming heat energy into mechanical work. Under this definition the word heat engine includes not only what is ordinarily called an engine, but in a steam plant it includes boiler, piping, engine, condenser, air pump and feed pump. All these are parts of the apparatus which transmit the energy from the furnace to the engine or turbine shaft.

The simplest conceivable heat engine requires four parts: A source of heat, a working substance that can be acted on by the heat and by its changes produce work, an engine proper in which the working substance acts, and a refrigerator to which the heat not used in producing work may be rejected.

The necessity for the first part is obvious—you must have a source of heat to run a heat engine. The necessity for a working substance may not be so obvious at first thought, but a very little study will make it clear. The technical definition of work is sometimes given as the action of a force through a distance. A more popular definition is that work consists of moving something against a resistance. Now the heat in the furnace of a steam plant, of itself, cannot move anything. If it is transmitted to the water, the latter expands in the formation of steam and will move the engine piston or turbine blade. In this case the water or steam is the working substance. It might be said that the heat will expand the parts of the boiler shell and so do some work. In this case the steel is the working substance and does work on the setting it displaces or on the atmosphere it pushes back as it grows larger. There have been engines built which developed power by alternately heating and cooling a metal bar, the movement of the ends of the bar being transmitted through ratchets to a rotating shaft. Of course such an engine develops very small amounts of power owing to the small changes in the metal bar, but it illustrates the fact that while a working substance is necessary, it need not be a liquid or a gas. Liquids, vapors and gases are generally used, however, because of their convenience.

Every engineer knows that a very large proportion of the heat of the steam used in an engine or turbine is thrown away in the condenser cooling water. Any suggestion that this heat be turned into power is met by the statement that this is impossible, that even in a perfect heat engine only a part of the heat can be used in the generation of power and that the remainder must be wasted. It is proposed here to explain the reasons for this statement and to show that it is true so that the non-technical man may appreciate just what are the limits of efficiency in a heat engine.

The need of an "engine proper" in which the working substance can act is also obvious. Its real function is to transmit the movement of the working substance to the point where we want the force to act.

The necessity for the fourth part of the heat engine, a refrigerator, or as it has been called, a waste basket for the unused heat, is not so clear. It is convenient here to consider another requirement of a heat engine. This is, that for continuous operation the working substance must go through a cycle. It must pass through various changes, but must be returned to its original condition and continue to pass through the same change over and over again.

As an example, consider a condensing steam-turbine plant. The feed water in the boiler is made into steam, passes through the turbine, is condensed in the condenser and is pumped back into the boiler ready to go around the circle again. A non-condensing plant which exhausts to the atmosphere may seem to depart from this cycle requirement. Consider a pound of feed water entering the boiler and follow it through the plant until it is blown out through the exhaust head on the roof. Now if the plant is to continue to run, another pound of water must be fed to the boiler. Suppose the original pound of water came from a near-by river and the second pound is taken from the same place. The boiler does not know whether it has a new, strange pound of water or whether the original pound was condensed as rain, fell back into the river and was drawn into the suction pipe. The important point to consider is that from a thermal standpoint the effect is the same whether we return the identical pound of water to the boiler or use a different pound. Someone may insist that we can have no real cycle unless the original pound of water is returned to the boiler and, further, that we have no assurance that this original pound does get back. Assume for the sake of argument that the second pound is not identical with the first and that a third different pound takes the place of the second, etc. If we keep this up long enough, all the water in the universe may have passed through our plant and we will either have to stop or use some of the water a second time. This simply means that we have enlarged our system until it includes the universe instead of confining it to the four simple parts we started with.

Let us now see just how the steam does work on the piston. Fig. 1 shows the section of an imaginary steam plant. *A* represents a boiler connected to the cylinder *B* by the steam pipe *C*. Assume that the cylinder has a cross-section area of 2 sq.ft. and a stroke of 5 ft. and that the steam pressure is 1,000 lb. per sq.ft. If the piston is in the head end of the cylinder, the volume of the steam and water in the system is equal to the volume of the boiler and steam pipe. Suppose now that the piston travels to the other end of the cylinder, the volume of the steam is increased by the area of the cylinder multiplied by the stroke, or $2 \times 5 = 10$ cu.ft. If during this time the fire under the boiler has been kept just right, the pressure will have remained constant at 1,000 lb. per sq.ft. and the total force acting on the piston was $1{,}000 \times 2 = 2{,}000$ lb. This has acted through a distance of 5 ft., so that the work done was

2,000 × 5 = 10,000 ft.-lb. This might have been written all together as 1,000 × 2 × 5 = 10,000 ft.-lb. If we multiply the increase in volume, 10 cu.ft., by the pressure in pounds per square foot, 1,000, we get the same result. To express it in general terms, the work in foot-pounds is the pressure in pounds per square foot multiplied by the area of the piston in square feet and the length of the stroke in feet. If these last three quantities are represented by P, A and L respectively, we may write:

$$Work\ done = P \times A \times L$$

The product of A and L, however, is equal to the increase in volume, so that the work done is $P(V_2 - V_1)$ where V_1 is the volume of the boiler and steam pipe and V_2 is the volume of boiler pipe and cylinder combined.

Now if we are willing to stop, we have put some heat into the water, the engine has done some work and the piston reached the end of its stroke. If, however, we want to continue to run the engine, the piston must be pushed back to the head end of the cylinder and this may be done under various conditions.

Assume first that the fire is kept burning and the piston forced back. Heat is being added by the fire, and at the same time the volume of the steam is being decreased so that the pressure must be increased. Under these conditions it is obvious that it will take more work

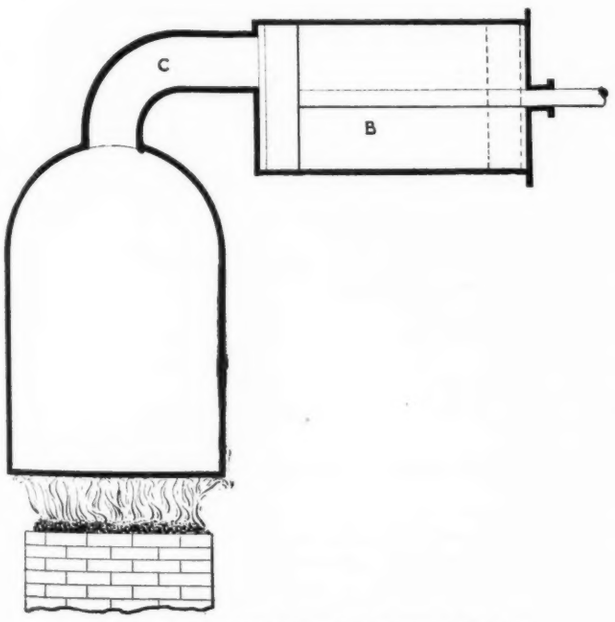


FIG. 1. IMAGINARY STEAM POWER PLANT

to force the piston back than was done by the steam on the piston during the forward stroke.

Suppose, now, that the fire is put out, but that the boiler, cylinder and piping are covered so that no heat is gained or lost. If the piston is now forced back, it is obvious that the pressure must rise, owing to the decrease in volume, although not so much as in the previous case. Under these conditions also the return stroke absorbs more work than the forward stroke produced.

It is obvious, then, that if the return stroke is to require less work than the forward stroke furnished, some heat must be taken out of the steam, or as it is usually expressed, some heat must be rejected. The rejection of heat necessarily implies some body to receive the heat, and it is this body which is referred to as the refrigerator in thermodynamic discussions.

In the actual steam engine steam is not admitted during the full stroke as in the imaginary engine just described. During admission the pressure remains practically constant and the steam in boiler and engine cylinder expands as in the case already described. After

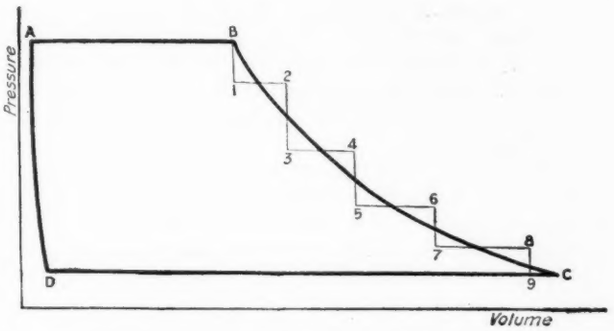


FIG. 2. PRESSURE-VOLUME DIAGRAM SHOWING STEAM CHANGES DURING A WORKING CYCLE

cutoff the steam in the boiler can no longer expand and as heat continues to be supplied, the pressure rises. The time until the engine valve opens for the next stroke, however, is so short and the amount of water in the boiler so large that the increase in pressure is in most cases unnoticeable.

Meanwhile, the steam in the cylinder is increasing in volume and decreasing in pressure. The work done during this part of the stroke may be computed by assuming a number of constant pressure changes at intervals. Referring to Fig. 2, the line AB will represent the changes during admission and the curve BC the expansion. The work done may be approximately found by considering the broken line $B,1,2,3,4,5,6,7,8,9,C$ instead of the curve, and the greater the number of steps taken the greater will be the accuracy. The work done on any "step" is of course the pressure multiplied by the change in volume for that "step," and the sum of all these products is the total work.

This steam must be put back into the boiler if the engine is to continue in operation, and the amount of work required to put it there depends on the conditions under which the pumping takes place. If we leave it in the engine cylinder and force the piston back without cooling the steam, the relations between pressure and volume will be the same as during expansion and we have to put back all the work we got out of the steam. Suppose, now, that the steam is left in the cylinder, but that it is cooled by some means so that, as the piston moves back, the pressure remains constant at the pressure existing at the end of expansion. This process is represented by the line CD in Fig. 2, and the work done is equal to the pressure multiplied by the change in volume between C and D. This of course will be much less than the work done when passing from A to B and then to C. If all the steam has been condensed at D, the volume at that point represents that of the water, which of course, is very small as compared to that of the steam. To get the water back to the condition at A, the volume will decrease very little as the pressure rises to A and the curve DA represents this change.

The same thermal effect may be obtained by condensing the steam in a condenser outside the cylinder.

The idea of condensing the steam inside the cylinder was used in the first engines and was not abandoned until Watt showed that a separate condenser was possible and an improvement.

A similar study of any other form of heat engine—a gas engine, an oil engine or a hot-air engine, for example—will show that in all cases the working substance must pass through a cycle or a continuous round of operations. This study will also show that it is necessary to throw away some of the heat supplied by the fuel. The first problem of engine design, then, is to select a cycle which will result in wasting the minimum amount of heat. In the year 1824 a French engineer named Sadi Carnot devised a cycle which is still known as the Carnot cycle.

Carnot showed that if an engine could be built to work on this cycle, the proportion of the heat that must be wasted would depend only on the temperature of the source of heat and the temperature of the refrigerator. He further showed that for any given values of these two temperatures, no engine could operate at a greater efficiency than one working on the Carnot cycle. If we let T_1 be the absolute temperature of the source of heat and T_2 the absolute temperature of the refrigerator (absolute temperature is the temperature read on a Fahrenheit thermometer plus 460), then the efficiency of an engine operating on this cycle will be $\frac{T_1 - T_2}{T_1}$, or as it is sometimes written, $1 - \frac{T_2}{T_1}$.

No engine can ever be built to equal this efficiency because of the limitations of the properties of materials, etc. The Carnot efficiency does, however, set a standard toward which we can work and to which we can compare all engines. It also indicates the limit beyond which it is impossible to go under any given set of temperature conditions.

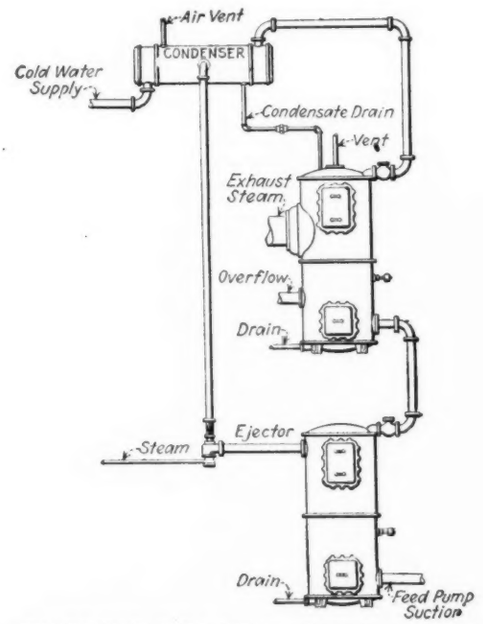
Air-Separating Process

Natural water as it is fed to boilers contains three classes of impurities—dissolved gases, dissolved solids and suspended matter. The purpose of this air-separation process is to remove the dissolved gases, but it also removes one class of the dissolved solids as well. Fundamentally, the process consists of heating the water to its approximate boiling point and then injecting it into a chamber under vacuum. The vacuum is maintained by an air pump with a condenser or heat exchanger in series, so that all the heat from the vapor exhausted from the region of vacuum is returned to the feed-water heater through the heat exchanger. The process operates at 100 per cent efficiency thermally, but thermodynamically the energy loss due to pumping from the region of vacuum slightly lowers the over-all efficiency.

Referring to the illustration, which is a diagrammatic layout of the system, which is manufactured by the Elliott Co., Pittsburgh, Pa., the sequence of the process is as follows: Water enters from the supply mains and passes through one side of the circulating system of the heat exchanger, from which it passes, still under supply pressure, to the inlet valve of the heater and is admitted to the heater under the control of a water-level float valve. Having been heated to the operating temperature of the heater, it passes under gravity head to a float-control valve of the separator. In proper time it passes into the separator, gives up its dissolved air, and the major part of the water passes through the separator to the pumps that supply the boilers. A small portion of it, however, is evaporated under vacuum conditions of the separator and is withdrawn mixed with air from the water by the air ejector producing the vacuum.

The mixture of air, vapor and ejector steam passes to the other side of the circulating system of the heat exchanger; the heat of the mixture is absorbed by the flow of the incoming supply water; the air escapes through the vent, and the condensate returns by gravity to the heater. The process has, therefore, lost no heat and no water, and only the air has escaped. This perfect head balance and the practically complete elimination of the air are the characteristics of the process. No heat as such is wasted, although some energy is consumed in pumping out the air and in overcoming the additional suction head on the boiler-feed pumps.

Irrespective of the arrangement of the auxiliary apparatus such as ejectors, heat exchanges, etc., the separating process may be applied to several conditions that are in line with rational practice. The separator may draw water from a heater and deliver the processed water to boiler-feed pumps for direct feeding to boilers. The separator may draw its hot water from a heater and deliver it through feed pumps to an economizer, or the separator may draw hot water from one section of an economizer and deliver it to another section.



DIAGRAMMATIC LAYOUT OF THE SYSTEM

The separation process removes nitrogen, hydrogen, oxygen and free carbon dioxide from the water. The first two of these are relatively inert, but the second two, oxygen and free or half-bound carbon dioxide, are responsible for the internal corrosion, which can be safely avoided by keeping the temperature of the water above the dew point of the flue gases. Under these conditions, the dew point being about 130 deg. F., there will be no condensation of acids from the gases and there will be no internal or external corrosion and no heat loss or operating charges.

Maintenance and Operation of Government Fuel Yard

THE responsibility for the purchase and distribution of fuel to Federal and municipal plants in the District of Columbia and surrounding territory, with the exception of the Navy Yard, has been vested in a Government fuel yard, provision for the establishment of which was made in the Sundry Civil Bill for the fiscal year 1918.

This yard is operated to insure the centralization of the purchase and distribution of Government fuel. Purchases are made at the mines. The object of the Government-operated yard is twofold—namely, to avoid the repetition of a coal shortage such as was experienced during the winter of 1917-18 and to provide facilities for taking coal into storage in the summer months as a protection to plants having but little storage space available.

STORAGE SPACE FOR COAL IN GOVERNMENT FUEL YARD

The installation of a permanent yard was started in the winter of 1918-19, but was not completed until the present fiscal year. In the study of different types of equipment consideration was given to the difference in summer and winter requirements as affecting the demands of motor equipment and labor, and to meet the situation an effort was made to so design the yard that the trucks could be loaded in a minimum length of time as well as with a minimum amount of labor. Consideration was given only to types of coal-handling equipment which provided for the unloading of incoming coal independently of delivery operations and, conversely, for delivery operations to be equally independent of the labor force engaged in unloading.

A conveyor system of handling was installed. Coal arriving on the main line of the railroad is switched to one of two spurs. Each spur has a capacity of 16 cars, 8 in the unloading space and 8 in the space for empties, beyond the hoppers. As the spur track has a down grade of 1½ per cent away from the main line, the cars are easily moved.

The coal descends through the hopper upon the conveyor running beneath it, which has a capacity of 250 tons per hour. In passing over the conveyor, it is automatically weighed by an electric conveyor scale after which it is delivered by the conveyors either direct to the loading bins or else to the storage spaces.

Contracts were given out for storage. The award was made on the basis of 69c. per ton for coal and $1.50 per cord for wood. The amount expended for this type of labor under the contract was $27,813.54. Believing that this cost was excessive, steps were taken to have the fuel yard's organization handle this phase of the work, with the result that a saving of $9,000 over the previous year was effected.

During the year 266,942.39 tons of coal, 689 cords

of wood, 1,122.2 bushels of charcoal and 22.9 tons of coke were handled. All but 73,463.58 tons was delivered by truck at an average handling cost of $1.138 per ton. In this cost is embraced the expense of rehandling, incident to the reclaiming from storage of 17,562.32 tons. The total cost of this fuel to the departments was $1,904,071.41. The basic cost to the fuel yard was $1,674,147.14, leaving a margin of gross profit of $229,924.37 for the total cost of operation.

The average cost per ton for the yard was 26.6c.; for the garage, 65c.; for overhead, 9.4c.; and for household improvements and depreciation of equipment other than motor equipment, 15.8 cents.

The expense of the yard and garage operations for nine months (October 1 to June 30) was as follows: Stacker and conveyor, $4,061.75; unloading cars (3.009), $6,409.05; reclaiming coal, $3,306.75; loading and weighing trucks, $2,096.15; overhead, $19,720.29. The overhead embraces such charges as rental ($9,250 per annum), power and light current ($3,243) and salaries of supervising employers and watchmen.

Spontaneous Combustion of Coal in "Silo" Bunkers

In the April 6, 1920, issue of *Power* was published an article dealing with the completed improvements of the coal-handling facilities at the Cos Cob plant of the New York, New Haven & Hartford R.R. The completed part of the system consisted of two cylindrical concrete storage bunkers (silo type) 40 ft. in diameter

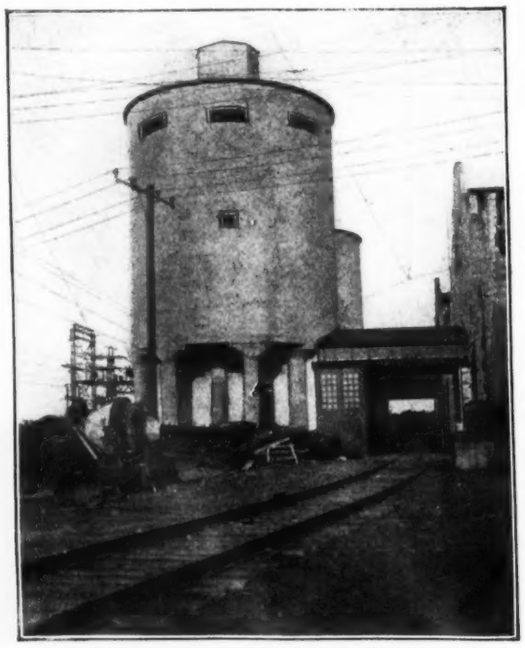


FIG. 1. COAL SILOS AT COS COB

and 46 ft. high, each having a capacity of about 1,000 tons of coal.

Since these bunkers were put in use, trouble has developed from spontaneous combustion. This has given rise to considerable apprehension because of the possibility of the gases rising from the coal becoming ignited and causing an explosion that might wreck the bunkers.

Spontaneous combustion with Pennsylvania run-of-mine was caused by masses of coal becoming packed around the bottom edge and between the outlets in the bottoms of the bunkers. When fresh coal was delivered to the bunkers, this solid mass remained in a packed condition and therefore did not move out to be replaced by the newly received coal.

It is understood that the storage bunkers were originally constructed with flat bottoms. In order to

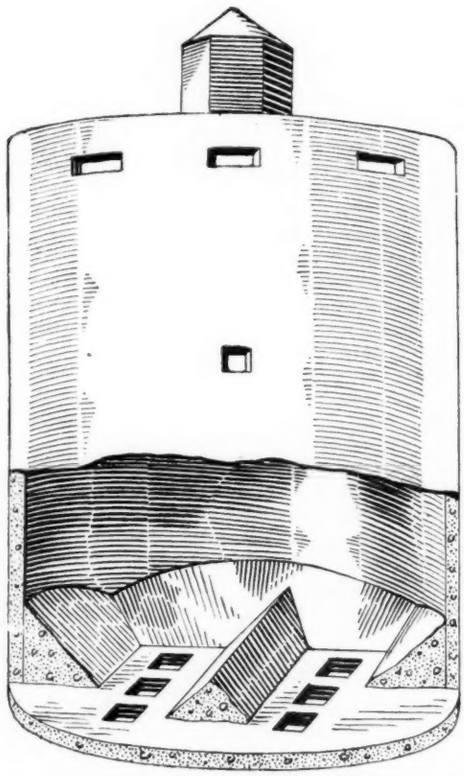


FIG. 2. SHOWING SLOPING-BOTTOM DEFLECTORS

facilitate the outflow of coal, sloping concrete deflectors extending from the outside wall toward the outlet gates were put in each, also an inverted V-shaped deflector running across the bottom of each bunker between the six outlets (see Fig. 2). All these deflectors have a slope of 45 degrees.

Even with this bottom construction the trouble from packing coal has not been entirely removed, and it is proposed, if it becomes necessary, to replace these concrete deflectors with iron ones set at an angle of 60 deg. In order to remove the packed coal from the center deflector, an 18 x 18-in. poke hole has been cut in the side of the bunker about 20 ft. from the bottom. This is to permit of loosening the coal with a bar from a platform on the outside.

In case of the coal catching fire, there is the danger of an explosion of the confined gases. The method adopted to clear the bunkers of these gases consists of a series of ventilating openings, each 18 by 36 in., cut at intervals around the top of the bunkers, so that no matter in what direction the wind may blow there will be a current of air flowing across the top of the coal and out through the opposite vent hole. It is thought that this will remove sufficient gases to prevent an explosion and to permit of men getting into the bunkers when necessary.

"Y"-Box Resistors and Their Uses

By H. C. YEATON

If it should be required to reduce the voltage of a three-phase three-wire circuit when transformers are not available, a "Y"-box resistor may be used to advantage in many cases. Fig. 1 shows a "Y"-box resistor connected to a three-phase three-wire circuit. The

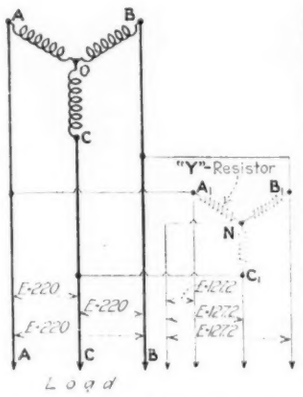


FIG. 1. "Y" RESISTOR CONNECTED ON A THREE-PHASE CIRCUIT

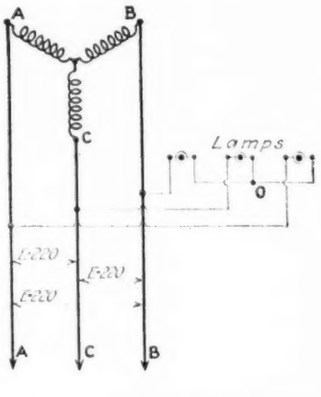


FIG. 2. THREE LAMPS CONNECTED TO FORM "Y" RESISTOR

voltage across each of the lines *AB*, *BC* and *CA* is 220 volts. A line is brought out from the neutral point *N* of the "Y"-box resistor, the voltage being reduced in the ratio of 1.73:1 or to 220 ÷ 1.73 = 127.2 volts between A_1N, B_1N, and C_1N. A_1N, B_1N, and C_1N have the same phase relations, respectively, as the legs in the main circuit *AO*, *BO* and *CO*. The amount of resistance in each leg of the "Y"-box resistor should be equal and should be designed so as to withstand, without overheating, any load to which it might be subjected. An experiment indicated in Fig. 2 might readily be performed to make the subject more clear. Take three ordinary lamps, rated at approximately 120 volts, and connect a terminal of each at a common point *O*. From the other terminal of each lamp connect a lead to each line of a 220-volt three-phase three-wire circuit. When connected in this manner, each lamp will have 127.2 volts impressed upon it, and all three lamps will burn at full brilliancy. Now disconnect one lamp lead from one line, and it is obvious that the remaining two lamps will be connected in series across 220 volts and the brilliancy of the two lamps will diminish. A "Y"-box resistor is used quite frequently with a single-phase indicating wattmeter when it is required to measure the power of a balanced three-phase, three-wire circuit as shown in Fig. 3. There are two resistance legs in the "Y"-box resistor, and the resistance of the potential circuit in the wattmeter forms the third leg of the "Y". The resistance in each leg of the "Y"-box is the same as that of the wattmeter's potential circuit.

The particular object of the "Y"-box, when used in connection with a single-phase wattmeter to measure the power of a balanced three-phase three-wire circuit, is to obtain the same phase relation between both the current and potential circuits in the wattmeter, as that of the phase in which the power is measured. In Fig. 3 the potential circuit from O_1 through the wattmeter has the same phase relation with the current circuit *C'* as the voltage and current of circuit *OC*. It is obvious that the wattmeter measures the current in the leg *OC*, and is connected across a voltage on the "Y"-box, which is the equivalent to the voltage across *OC*. This therefore measures the power in the *C* phase of the circuit, and as there are three phases, the scale reading on the single-phase wattmeter should be multiplied by 3 to obtain the total power of the circuit.

Frequently, it is desired to use a single-phase wattmeter to measure the power of a balanced three-phase three-wire system, when the voltage of the circuit is in excess of the voltage rating of the wattmeter. This can be accomplished by means of a "Y"-box multiplier, as shown in Fig. 4. Assume that a 2 : 1 multiplier is required to adapt the single-phase wattmeter to measure the power of a circuit of which the line voltage is twice that of the meter. The resistance in the "Y"-box multiplier from O_1 to *X* should be equal to the resistance of the wattmeter potential circuit, and the resistance in each leg of the "Y"-box multiplier from O_1 to A_1 and from O_1 to B_1 should be equal to two times the resistance of the circuit O_1X. To obtain the correct power in the three-phase three-wire circuit, the single-phase wattmeter readings should be multiplied by 3, the same as described in Fig. 3, and also by 2, since the multiplier has a ratio of 2 : 1.

"Y"-box multipliers, for other capacities, for use with a single-phase wattmeter to measure the power of a three-phase three-wire circuit can be calculated in the same way as described. Like all electrical resistances, "Y"-box multipliers should be so selected or designed as to withstand the watt load to which they will be subjected, without overheating.

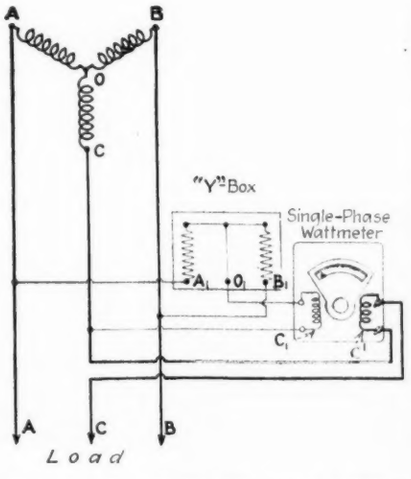


FIG. 3. SINGLE-PHASE WATTMETER CONNECTED THROUGH "Y" RESISTOR

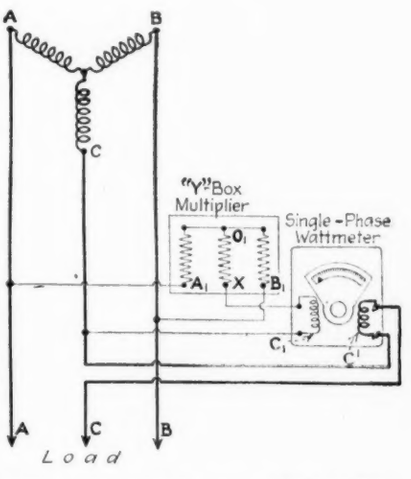


FIG. 4. SINGLE-PHASE WATTMETER CONNECTED THROUGH "Y"-BOX MULTIPLIER

Refrigeration Study Course—XV*
The Absorption Machine

By H. J. MACINTIRE
Professor of Mechanical Engineering, University of Idaho

SO FAR in this study course little has been said of the absorption refrigerating system, the type of machine that is least understood in refrigerating circles. However, this machine is important, is adapted to certain kinds of work and will continue to be sold and used for many years. It has, however, its particular sphere, and the future will see it more particularly confined to these limitations. For example, it cannot be operated with success without steam. But the high steam-pressure absorption machine is seldom used now, because as a rule the same result may be obtained much more economically by use of low-pressure (exhaust) steam or by the use of a steam-driven compressor.

Using exhaust steam in the absorption machine, a ton of refrigeration may be obtained for about 30-35 lb. of steam, or about the rate required in certain types of steam-driven compressors. In other words, we can practically double the tonnage, using the same steam, by the addition of the absorption machine. Is this a case of "getting something for nothing"? The answer is, no. We simply employ another machine, more investment and much more engine-room space to the purpose of securing greater economy.• But are there any other advantages besides the use of exhaust steam (like exhaust-steam heating) for the production of refrigeration?

Yes, the one other great advantage of the absorption machine lies in its ability to secure a low temperature with slight increase of expenditure of power. As has been pointed out a number of times in this study course, the compressor gives the maximum economy with the highest possible suction pressure. This is because the tonnage varies directly as the number of pounds of ammonia condensed and later evaporated in the expansion coils. But this number of pounds varies with the so-called specific volume of saturated ammonia, which in turn varies indirectly as the absolute pressure. At low pressure this specific volume (the volume in cubic feet occupied by one pound) is so great that the standard compressor is frequently expressed as being only "fanning a vacuum." The standard compressor is unsuited for such service, as it has greatly reduced capacity and tends to overheat the ammonia on discharge. As has been considered already, for low temperatures use should be made of compound compression and not of the standard form of compressor. But how about the absorption machine? How does it work to secure economy at low refrigeration temperatures?

The Absorption Machine in Action

The absorption machine is not a displacement pump in the sense of the compressor. The gas is carried over from the low-pressure side to the high-pressure side in the form of a solution at much reduced volume. For example, 5, 10 or 15 lb. of solution will carry with it a pound of anhydrous ammonia. This aqua (solution of water and ammonia) occupies $\frac{1}{12}$ to $\frac{1}{4}$ cu.ft. of space per pound of ammonia delivered irrespective of the pressure on the low side, which might be (for the one pound) 15, 20 or even more cubic feet. This peculiarity of forming a solution (weak aqua) is not absolutely liquefaction. It is simply a fact that water has the ability to dissolve a large amount of ammonia, say 500 to 1,000 volumes.

The result of the cycle of operations is that the ammonia may be boiled at any temperature, practically, and the gas formed will be conveyed to a so-called absorber. In the absorber the gas enters solution and the aqua formed in the process is pumped back into the "still" again, which is arranged for suitable heating by means of exhaust-steam piping (see Fig. 1). The exhaust steam heats the aqua (so-called strong aqua) in the still or generator and drives off a vapor mixture of steam and ammonia, the steam being almost entirely separated from the ammonia before condensation occurs in the ordinary type of ammonia condenser. This action is similar to that taking place with ordinary distilled water, oil refineries and in other industries. The idea is simply that a certain *concentration* of aqua —when heat is applied—will boil ammonia gas, and the boiling pressure is the vapor pressure in the condenser. Also, that boiling will continue until a certain concentration is obtained of solution in the still, unless the temperature of the aqua in the still is increased, in which event boiling will continue. As the temperature of the still is held constant, then to have continuity of boiling it is necessary to keep up a steady addition of strong aqua and allow the weak aqua (the strong aqua after boiling away the ammonia gas) to pass out of the still (also called a generator).

The Weak Aqua Absorbs the Gaseous Ammonia

The weak aqua from the still is made to go into the absorber, where it meets the gas produced by the action of boiling in the refrigerating coils (see Fig. 2). The gas comes into the absorber and is thoroughly mixed with the liquid weak aqua in a manner similar to the steam-jet condenser; that is, the gas is apparently condensed and carried away. There is, however, no real analogy between the absorber and other steam-power-plant equipment. The weak aqua does actually condense the gaseous ammonia and then absorbs it, forming thereby a stronger solution or concentration. This strong solution is called the strong aqua, and it leaves the absorber at a low pressure (the pressure in the refrigerating coils), a low temperature, but a strong concentration. It is the difference in the concentrations of the weak and strong aqua which materially affects the economy of the absorption refrigerating machine.

In a heating plant it is usual to see the boiler and steam distributing systems, the condensate return and the hotwell or tank, but there is always a boiler-feed pump to return the condensate from the hotwell to the boiler again. This is because the condensate line is at or near atmospheric pressure and the condensed steam

*"The Refrigeration Study Course" article in the August 24 issue should have been numbered XIV instead of XVI.—Editor.

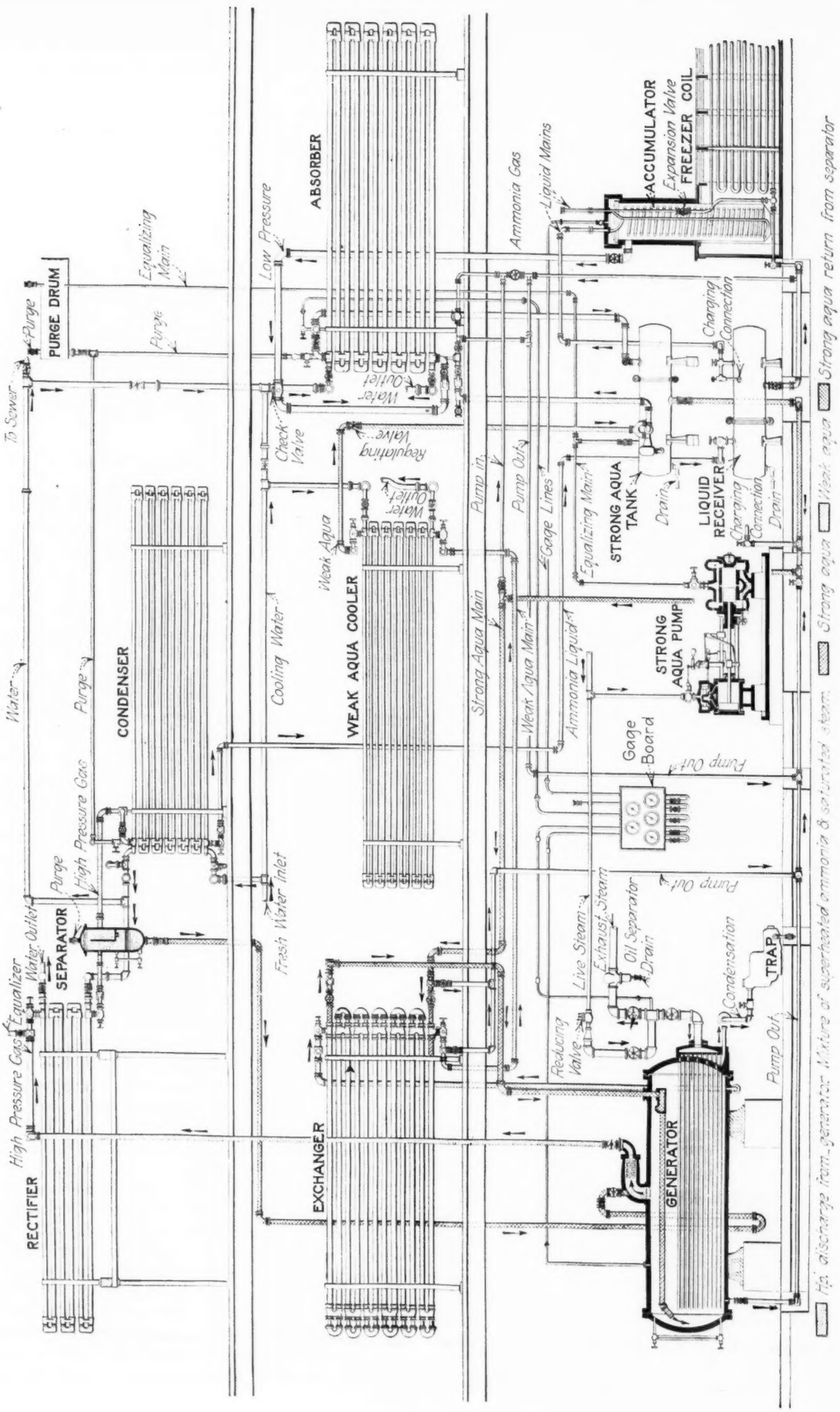


FIG. 1. LAYOUT OF TYPICAL ABSORPTION REFRIGERATING SYSTEM

and makeup cannot of itself return to the boiler. The same is true of the strong aqua of the absorption system, which is subject to the pressure of the low side and naturally cannot return to the still without assistance. This end is achieved by means of a strong-aqua pump, designed especially to handle a liquid which is readily volatile.

The strong-aqua pump returns the strong aqua to the top of the still, but in between the pump and the still is the so-called exchanger. The exchanger is usually a double-pipe apparatus designed to improve the economy of the plant. If one examines into the case, it is seen that the weak aqua leaves the still in a very hot condition. The strong aqua leaves the absorber in a relatively very cool condition. The exchanger is simply a counterflow set of piping arranged to cool the weak and heat the strong aqua. The strong aqua returns to the still with a temperature not much below that of the aqua in the still. Incidentally, the weak aqua has to be cool (like steam condensing water) to enable it to absorb more gas. The exchanger also aids in providing better economy by requiring less cooling water to be supplied to the absorber.

The only other special piece of apparatus in the absorption system is the device placed between the still and the condenser. This is a water-cooled rectifier,

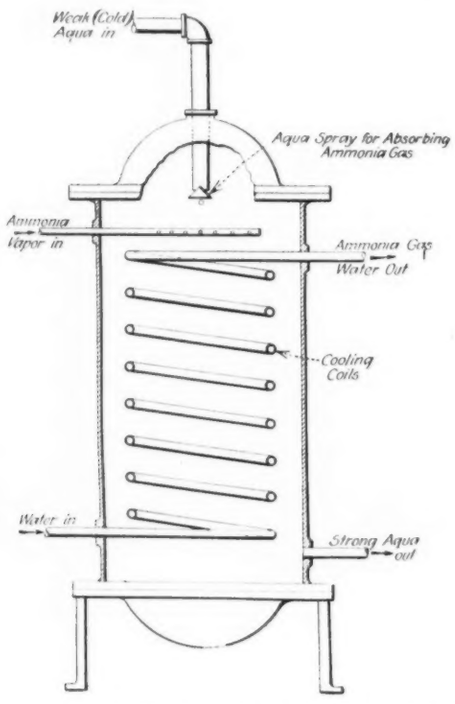


FIG. 2. CONSTRUCTION OF AN ABSORBER SIMPLIFIED; NOTE SIMILARITY TO JET STEAM CONDENSER

or dehydrator, used to remove the greater part of the steam in the gas from the still. It seems that during operation the gas leaving the still is superheated in the same manner as the discharge gas of the compression machine. It contains also some 10 to 20 per cent steam. To separate the steam from the ammonia, it is usual to pass the mixture through a system of piping which is water-cooled and to cool the gas to a point some 15 to 20 deg. above the point of saturation (the temperature corresponding to that of the condenser pressure). During the cooling process most of the steam is condensed and returns as a strong aqua to the still again by gravity (see Fig. 3).

It is therefore seen that the absorption refrigerating system is more like a steam-heating plant except for the addition of certain special pieces of apparatus. The plant has a single moving machine, namely, the strong-aqua pump (provided the cooling and condensing water

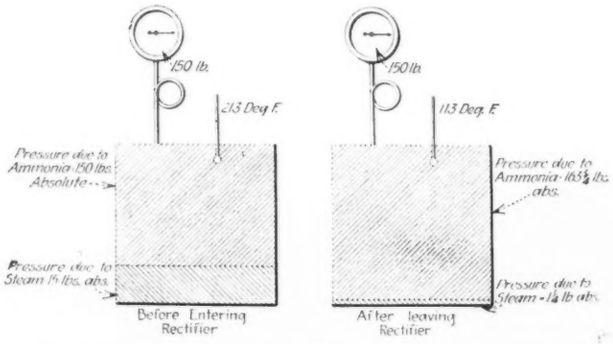

150 lb.
213 Deg. F.
Pressure due to Ammonia-150 lbs. Absolute
Pressure due to Steam-14 lbs. abs.
Before Entering Rectifier
150 lb.
113 Deg. F.
Pressure due to Ammonia-16.5 lbs. abs.
Pressure due to Steam-1.4 lb. abs.
After leaving Rectifier

FIG. 3. ILLUSTRATING ACTION OF THE RECTIFIER

does not require pumping). The plant is also like a distilling system and, when understood, will give satisfaction. However, the amount of useful refrigeration performed is directly proportional to the difference in the concentrations of the weak and strong aqua. Also, the amount of liquid ammonia condensed in the condenser is directly influenced by the concentration, steam pressure and ammonia pressure in the still. It may be necessary to increase the concentration or the steam pressure (or reduce the condenser pressure) to get proper results, but when properly installed and maintained, the absorption machine gives excellent results. The machine is bulky, expensive in first cost and requires more water for cooling purposes. The absorption machine requires cooling water on the condenser, the absorber, the weak-aqua cooler and the rectifier. Whereas at times it is possible to use the cooling water successively in a number of these portions of the machine, yet sometimes two or more times as much water is required as for a compression plant of similar size where cooling water is required on the condenser and the compressor jackets only.

The particular advantages in the use of the absorption machine lie in the relative ease in securing low temperatures and in the ready use of exhaust steam after use for power purposes. Where high-pressure steam has already been used and is available as exhaust steam in sufficient quantities at nominal book value (or as a waste product) the absorption machine is readily applicable. The economy of operation must, however, overbalance the increased first cost, additional engine-room space and the occasional difficulty in securing efficient operating engineers.

It is natural to expect the absorption machine to be found in combination plants of all sorts, where, instead of running the steam engine condensing, the exhaust is sent through the coils of the generator. In general it does not pay to operate small steam engines condensing, and *no single-acting steam engine* of standard make should be so operated except as a means of securing condensed steam. The reason for this is because the so-called cylinder condensation becomes excessive where the range of temperature in the cylinder is large.

Therefore compounding should be employed when a condenser is used. And, therefore, engines of about 100 hp. and under should be simple engines and should not be run at a vacuum—here the absorption combination plant will fit.

In plants using considerable auxiliary steam-driven machinery the exhaust of which is not needed for boiler feed, the absorption machine may be used to advantage. And most certainly where low temperatures are desired, as in sharp freezers or in any industrial plant where brine at zero degrees F. is specified, the absorption may readily find its place. *Power* readers have noted the description of the Quincy Market Cold Storage and Warehouse Co.'s plants, and that it has been possible to work in the absorption machine to advantage. Also it will be remembered that the oil refineries are strong for this machine because of the low-temperature brine which they think they have to employ. The author believes that the absorption machine is valuable in special and particular cases.

Show This to Your Coal Dealer

"This award . . . offers no justification for any advance in the retail price of coal, but on the other hand is consistent with a decline in prices."—*Report of the Anthracite Coal Commission.*

Diesel Pipe-Line Station Fire

On June 2 the destruction by fire of the Greeley (Kansas) pumping station of the Prairie Pipe Line entailed a loss of $1,250,000. Viewed from the standpoint of the Diesel-engine manufacturer, the loss is far greater, since the fire has caused this particular pipe-line company to abandon the proposed plan of replacing all the present steam plants with the Diesel units.

The Greeley station was a combined steam and Diesel plant, although the steam unit was not in use at the time of the fire. The engine house contained one triple-expansion National Transit steam unit, two 450-hp. Snow Diesel units, two 650-hp. McIntosh & Seymour Diesels and one 600-hp. Snow which had not been entirely installed. The National Transit steam cylinders formerly had been connected to the pump, which was being driven by a No. 3 Snow Diesel.

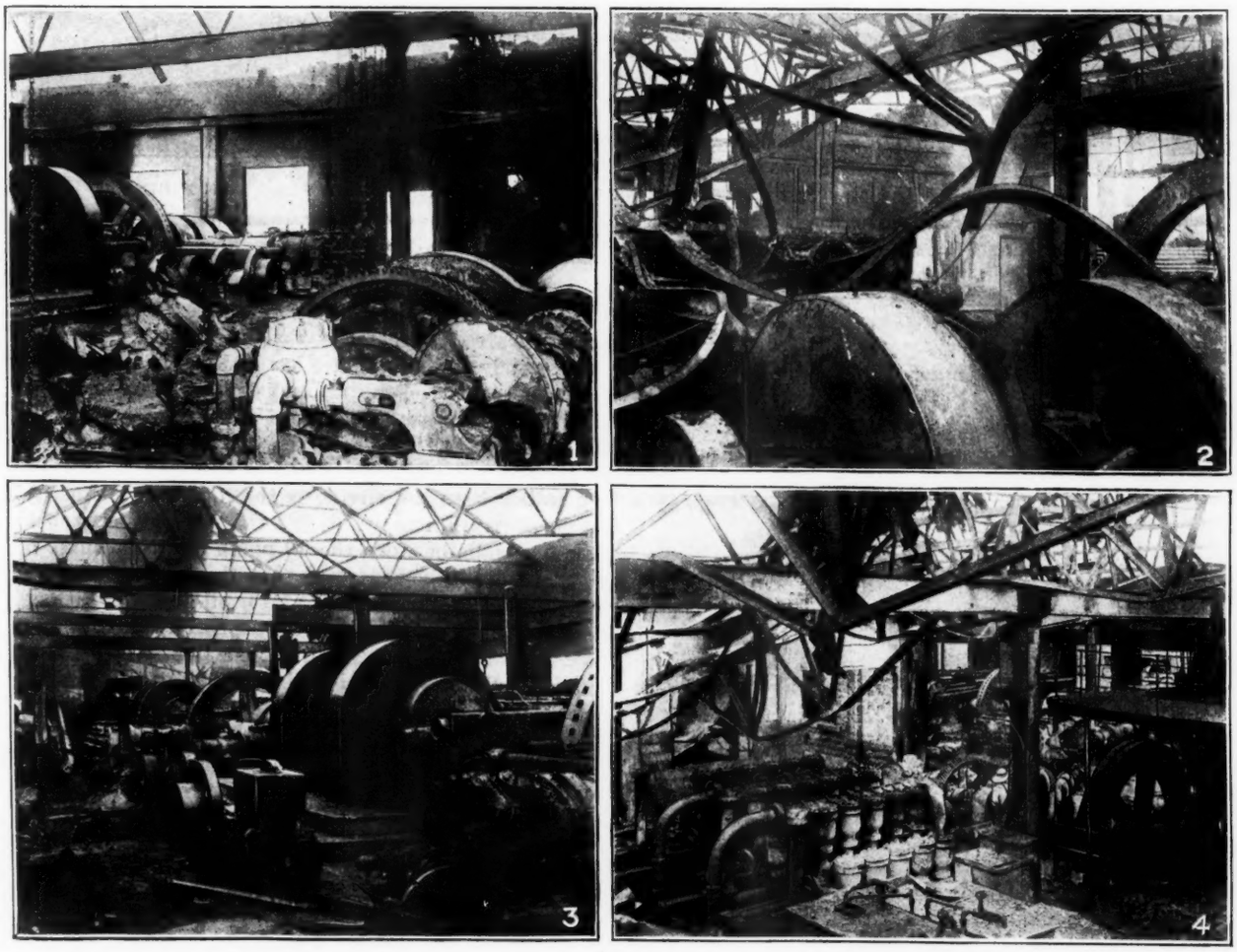


FIG. 1. GREELEY STATION FOUNDATION PLAN. FIG. 2. NO. 2 McINTOSH & SEYMOUR AND NO. 3 SNOW. FIG. 3. NO. 1 AND NO. 2 McINTOSH & SEYMOUR ENGINES. FIG. 4. McINTOSH & SEYMOUR ENGINE WITH PUMP

It will be seen from Figs. 1 to 4 that the fire destroyed the entire engine room. The boiler house, which appears at the left in Fig. 5, was entirely separate from the engine room and so escaped destruction. In addition to the loss of the plant a vast amount of oil was burned. The discharge lines from the several pumps passed through a valvehouse where the various gate valves were located. The fire was so intense that

the valvehouse was destroyed. The discharge lines from Greeley to Osawatomie, Kan., are on a rising grade; the contents of eighteen miles of six 6-in. lines flowed back into the engine room and increased the loss. The oil flow was finally stopped by cutting into the lines. The flow of oil continued for about seventy-two hours.

The immediate cause of the fire has not been fully determined as there were apparently two possible ways whereby the initial explosion could have been produced.

The pumps are rated at 2,000 bbl. of oil per twenty-four hours and have a discharge pressure of about 700 lb. A flow developed in one of the discharge manifolds of the pump geared to the No. 1 McIntosh & Seymour engine. The oil, as it issued from the fracture, was broken up into a fine mist by the high pressure. The air within the building imemdiately became saturated with oil particles. As soon as the break occurred, the engineer stopped the Snow engines and the No. 2 McIntosh. It was impossible to get to the No. 1 engine, and the engineer left the building. He was joined by the oiler, and the two then started away from the structure. They had gained only a few yards before the explosion occurred. After the fire the No. 1 engine throttle lever was found in the "stop" position, both men disclaim recollection of having stopped this engine. As soon as the explosion occurred, the roof fell in and the whole building became a mass of flames.

Several features of the plant layout constituted fire hazards, and it is impossible to determine with any degree of exactness where the fault lay. The oil-pipe lines within the building were placed in pipe chases or trenches which communicated with the trenches con-

FIG. 5. PRAIRIE PIPE LINE STATION FIRE, GREELEY, KANSAS

taining the exhaust pipes of the Snow engines. These exhaust lines were not water-cooled and were protected by asbestos lagging, which was somewhat broken in several places. The McIntosh & Seymour exhaust lines were water-cooled and ran across the building on a level with the cylinder heads. The air-suction lines for the working cylinders and air compressors of the Snow engines had their intakes outside the building. The McIntosh & Seymour engines secured their air from within.

It is claimed by some of the Prairie officials that the oil which saturated the air inside the building was drawn into the McIntosh air compressor and that as soon as it reached the high-pressure stage the temperature was high enough to ignite the oil. On the other hand, it is claimed by some, more familiar with the actual working conditions in this plant, that on several occasions oil had gotten into the pipe trenches and had ignited on coming into contact with the Snow exhaust pipes. Furthermore, the fire at the Buckner (Missouri) pumping station was caused by hot exhaust pipes. The Greeley station engineers claim that two

FIG. 6. PLANT AFTER THE FIRE

explosions occurred; that the first was heavy, while the second, which quickly followed, was comparatively light. The latter was probably the explosion in the McIntosh air compressor, which was totally destroyed.

As already stated, this fire has had a very detrimental effect on the Diesel-engine industry. To an impartial observer it appears that there is no excuse for the condemnation of the Diesel engine; indeed, it should not even be on trial. Certainly, the method of installation rather than the engine is the underlying cause of the disaster. Formerly, it was the general practice to place fire walls between the oil pump and the source of power. It is to be regretted that this wise precaution was abandoned in many of the later oil-engined stations. At present many of the pipe-line companies are building these fire walls in their unprotected plants. No Diesel engine should be installed without provision for water-cooling the exhaust lines. More fires are caused by neglect in this matter than by anything else. Similarly, good engineering practice dictates the location of the air supply for both the working cylinder and the air compressor outside the building. If oil engines are installed properly, there is no danger of fire.

According to the *Electrical Review*, London, the paper mill and sulphite factory at Vargo, Sweden, which were destroyed by fire in 1918, have been rebuilt and again set in operation. Owing to the difficulty experienced in obtaining coal the directors of the Vargo company, in connection with the work of reconstruction decided to adopt electricity throughout, including the use of electrical boilers in the steam plant, and the works now consume no coal, whereas 20,000 tons per annum would be needed under former conditions. The boiler house contains seven "electric" boilers, each of 3,000 hp. Current is used in the boilers at 10,000 volts. Each boiler is provided with three electrodes, and the connection arrangements are such that steam generation can be regulated within 5 per cent. It is stated that full steam pressure can be raised in from five to ten minutes after switching on the current, and considerable economy in attendance is obtained, as compared with coal firing.

EDITORIALS

Power Development at Niagara Falls

NIAGARA FALLS has become practically synonymous with power and scenic beauty. One can hardly be considered without bringing the other to mind. There are few of nature's spectacles that surpass or even equal the esthetic grandeur of Niagara Falls, as there are also few sites in the world that can compare with it in hydro-electric power-development possibilities. Approximately, one million people visit Niagara Falls each year to view the beauty of the falling water, and each year there are billions of kilowatt-hours generated from the potential energy stored in this water. Intelligently controlled and utilized, Niagara Falls is capable of developing millions of horsepower instead of a few hundred thousand at present, and still retain its present natural beauty.

In this issue the leading article deals with power development at Niagara Falls, especially the most recent, which consists of three 37,500-horsepower units. This installation has many features of particular interest. It represents a distinct advance in hydro-electric engineering. This is all the more worthy of notice, since the project was conceived under the stress of war and a considerable portion of the work was carried to completion under these conditions. This development may be considered as one of the benefits coming to this country as a result of the war, since it was brought about by a serious shortage of power for the industries at Niagara Falls, vital in the production of war materials. This shortage made it imperative that the War Department do something to relieve the situation and sanction the utilization of the remaining water allowed to be diverted for power development by the treaty with Great Britain. As a result we have one of the most efficient water-power developments in the world today—a development that is not only of paramount importance to our industrial progress, but also makes possible a saving of approximately five hundred thousand tons of coal per year.

The efficiency of these machines is higher than that ever attained before for units of this type, ninety per cent of the total energy in the water being delivered at the generator terminals. A feature that contributes considerably to the efficiency is the two types of draft tubes used—one the White hydraucone regainer and the other the Moody spreading type. These tubes make it possible to recover approximately eighty per cent of the velocity head in the discharge. From the results obtained by the use of these draft tubes so far, it is apparent that they make possible far-reaching developments in hydro-electric engineering.

When the first plant was built that may be considered an attempt to develop power from Niagara Falls on a large scale, it was an undertaking that taxed the engineering talent of both America and Europe as well as the manufacturing facilities. From first breaking ground for the plant in 1890 five years was required before the first unit was put into operation—one of three 5,500-horsepower machines. In the latest development, nineteen months after permission to go ahead with the work was granted by the War Department, the first unit was put into operation and a month or so after the two other machines were put into service. In this case the three machines have a capacity of seven times that of the first units, and develop twenty-two horsepower per cubic-foot-second where the former developed only approximately eleven horsepower. The latest development is the work of the engineers of one company, and the machinery was designed, built and installed by American manufacturers. This achievement in itself shows the progress made in hydro-electric engineering in this country in the last thirty years.

Although this new development involves the design and construction of the largest hydro-electric units in the world and the whole project all the way through has proved to be one of the most successful pieces of engineering work of its kind ever undertaken, it nevertheless can hardly be compared with the project started in 1890. One was strictly the blazing of a trail into an unexplored region, the other the crowning achievement of thirty years' experience in the field.

Securing Maximum Efficiency from Oil Engines

THE Diesel and semi-Diesel oil-engine market is somewhat disturbed by the soaring price of fuel oil. The oil which could be purchased for two and one-half cents per gallon a year ago is now being quoted at eight to ten cents. This increase, while startling, would not be of any general importance if the oil engines now in operation were being run at their maximum efficiencies. Any modern Diesel can deliver a horsepower-hour on four-tenths of a pound of fuel. Unfortunately, only a handful of stations attain a fuel consumption of less than one hundred and fifty per cent of this amount. With two hundred and fifty thousand horsepower of Diesels in operation the fuel lost in one year due to inefficient operation amounts to some fifty million gallons. This represents a considerable loss of money. Of more moment, however, is this waste when considered as an unnecessary destruction of natural resources. The loss due to inefficient operation of the semi-Diesel engine is of equal if not greater amount.

It is useless to ask the operator of the average oil-engine plant to adopt more efficient methods. He is not equipped with the means of checking the results he does obtain. In the modern steam plant the engineer has coal and water weighers, indicators, CO_2 recorders and numerous other instruments to reveal losses. In the oil-engine station even an indicator is seldom seen and less often is it used. There is every argument in favor of efficiency instruments, and it happens that with the Diesel plant only a few are required. An indicator is especially required and should be used at least once a week to check valve settings. A CO_2 recorder should be attached to the exhaust lines. One of the recording type is desirable. Furthermore, pyrometers should be

used on the exhaust lines from each engine. With such an equipment any imperfect combustion in the engine cylinders would be revealed by the lowering of the CO_2 percentage in the exhaust. A variation in the reading of the pyrometers would at once indicate an unbalancing of the cylinders. Proper means could then be taken to secure an even distribution of the work in the engine cylinders.

If the power-plant owner hopes to secure the efficiency which he has been led to believe the Diesel possesses, such accessories are necessities. The oil-engine manufacturer can assist the Diesel to attain the popularity it deserves if he will see that each plant sold is completely equipped with efficiency instruments.

Supply and Demand and Coal Prices

THE price of coal is high, we are told, because the demand exceeds the production. Stocks have been drawn down far below the safety limit, and consumers know it. Production, although gaining, is at too low a rate to assure us of reaching a safe level of reserves before winter.

And so, in obedience to the implacable, the inviolable, the sacrosanct law of supply and demand, the price goes up and it is almost impious to complain.

But in the summer of 1919 the mines were idle a great part of the time for lack of orders. Plenty of railroad cars were on the tracks empty, waiting for loads of coal. Buyers knew this, and they knew that in obedience to the high and holy law of supply and demand the price of coal ought to drop.

But it did not!

Prices were kept up to the war level, and the public was beseeched in flaring advertisements, in newspaper interviews and in pronouncements by those in high places, to buy early and avoid the rush.

Now the consumer is told that the present shortage is his own fault; that he used up his reserves instead of buying when plenty of coal could have been had—at a price—and provoked the big coal strikes by forcing the miners to idleness.

Can it be that somebody has hitched a pawl-and-ratchet attachment to the implacable law?

Coal Storage and Mechanical Coal Handling

SECURITY in power-plant operation, whether private or public utility in nature, demands greater coal storage these days than in the days when railroad transportation was almost always adequate. The power-plant executive is, therefore, today confronted with a new problem in coal handling on a large scale. This comes most unfortunately at a time when every effort is being made to cut down the amount of labor required. However, the engineer has available many mechanical facilities for coal handling that are proving most efficient in practical operation. The report of the chief engineer of the Government Fuel Yards in Washington on the operations for the fiscal year ended July 1, 1920, give additional encouragement in this direction. These yards, handling over 250,000 tons of coal per year, have been operated with unexpectedly low costs, especially when one considers the conditions under which official work of this sort must be maintained. The chief engineer reports a total of 23.6 cents per ton as the yard operating expense for handling this fuel. This includes unloading from the cars, delivery either to trucks, truck bunkers or stock piles, reclaiming from stock and all related expenses. The total expense reported, $1.13 per ton, embraced not only these yard operations, but also the total garage and the trucking expense of sixty-five cents per ton, the overhead expenses of about nine cents per ton and depreciation and leasehold improvements, sixteen cents per ton.

Engineers confronted with the problem of irregular fuel deliveries—and what engineer is not so bothered?—can well consider whether machinery does not hustle better than men and whether some mechanical stocking and reclaiming systems, even one operating on a small scale, will not be essential in the future. This situation, of course, is further aggravated when high demurrage rates are imposed and the one-day rule prevails with respect to unloading coal cars. It seems that the problem will be important to everyone, regardless of whether he is confident the coal situation is going to be worse or better.

Respect for the Man Who Knows How

WISE indeed is the engineer who organizes his men to care for all unusual situations, even to emergencies. Unfortunately, some men do not and cannot keep from elbowing their way into jobs which their crews are doing well. If the chief "drops in" just to see how things are going and departs when he finds them satisfactory or after giving directions, his men not only do the work better, but have a higher regard for him than if he rolled up his sleeves and did the job himself.

There are times, however, usually emergencies, when the chief can endear himself to his men and command their undying respect and admiration. Of course he must be capable and unhesitatingly sure that he knows how to do the job or meet the situation before he "jumps into it" himself. The bluffer has no place here; such occasions demand a thoroughly practical knowledge of the fundamentals involved, plus a sureness of action that puts confidence into the frightened or puzzled crew that called on the chief when their combined ingenuity and knowledge failed.

Some men give considerable thought about just what to do and in what sequence, should this or that accident or emergency happen. Such a habit of thought leads to preventive measures to lessen the possibilities of accidents and emergency. It is a good habit to encourage.

The American Society of Mechanical Engineers has added a commendable feature to its election machinery in a pamphlet giving pictures and biographical sketches of the nominees for the several offices. The membership, even in a year when there is no contest, is given in this way a new interest in the personnel of the executive organization and an indication to which it is entitled of the probable attitude of the candidates upon policies in which the members may be interested.

The coal users of the country cannot individually protect themselves from the extortion which they are suffering at the hands of the coal dealers, but when united action by the people as a whole, governmental action, is urged, there goes up a wail of "Government interference."

CORRESPONDENCE

Why Not a License Law?

In reference to the letter by Mr. Webber on page 147 of the July 27 issue, I wish to say that New York has as good a law as any state in the Union, as regards the manufacture and inspection of steam boilers. Mr. Webber severely criticizes the civil service boards, stating in effect that politics is played, but this is not always the case. He also mentions a case in which an engineer should have received the appointment.

I have sometimes heard that all boiler inspectors' positions should be filled by engineers, but I will say that the boilermaker, the man who builds and repairs the boiler, certainly knows what he is doing and is just as well qualified to inspect as any engineer.

Mr. Webber relates an instance where a new boiler was purchased, which, it was claimed, lasted only eleven months before it was found pitted to such a condition as to render it unfit for service. The only reason given was that rain water had something to do with it, but for my part I would say that I hardly consider this a satisfactory explanation, for I have never before heard of a new boiler lasting such a short time. I really believe the purchaser got a second-hand boiler and that a fresh coat of paint was all that was new about it.

Of course we all realize what took place years ago, but matters have changed, for we now have up-to-date laws in regard to manufacture and inspection. I sincerely believe, with Mr. Webber, that we should have an examination for the operator of steam boilers, but because a boiler explodes it is not altogether the operator's fault. CHARLES W. CARTER, JR.

Olean, N. Y.

We want no political license, but we do want a license to protect the engineer holding it. If an engineer is given a license, give him what goes with it. A licensed engineer surely knows enough about his plant to tell what is needed and when it is needed. No sane engineer would put his company to a lot of unnecessary expense by ordering a lot of useless material.

In a certain plant there is a 40-hp. return tubular boiler. They have kept loading onto this poor little kettle until it requires nearly 100 hp. to run the plant. Now the owners are thinking of putting in forced draft and burning hard coal under this boiler. It was washed out July 17 for the first time in ten months and about a hundred pounds of loose scale was removed; it is nearly ½ in. thick on the tubes and tube sheets. A worthless compound is used, but the boss knows more than his engineer. In order to clean the lower 1-in. gage-pipe connection to the water column it was necessary to break a cross-connection and then drive a ½-in. rod through both ways in order to clear it. Before this was done, it required about ten minutes for the water to show after blowing down the water column.

When cleaning the combustion chamber, it was found that the back plate yoke had broken and fallen into the soot. The manhole plate had leaked so badly that the soot was wet. R. G. SUMMERS.

Syracuse, N. Y.

What of Lower Coal Prices?

We are writing to ask if there are any prospects of a lower price for bituminous coal within the next few months. Is the Government going to make some effort to regulate the price?

It is our belief the Government should have taken the subject in hand a long time ago and not have let the situation come to such a state. Our Government does not seem able to grasp matters very well. Things of public welfare seem to be ignored and left to drift according to fancy. BAINBRIDGE REPUBLICAN.

Bainbridge, N. Y.

Definitions of Efficiency

D. M. Taylor, in his article, "What Is the Efficiency of a Steam Engine?" page 178 of the Aug. 3, 1920, issue of *Power*, has carefully discussed and explained the various definitions of efficiency used on steam-engine work. The only exception that might be raised is to the use of the term "cylinder efficiency" for the ratio of the heat turned into work per pound of steam to the heat available per pound of steam from adiabatic expansion from the initial steam conditions to the final pressure.

In the first place the term "cylinder efficiency" is confusing, since it has been proposed to use this term for an entirely different factor when applied to an air compressor or to vacuum pumps. Furthermore, the use of the term "cylinder" is not logical, for the ratio to which Mr. Taylor refers is frequently expressed on the basis of work measured in brake and even in electrical horsepower. This expression of efficiency has been used and popularized by the manufacturers of steam turbines both here and abroad, who have referred to this factor usually as the "efficiency ratio referred to the Rankine cycle" or in short as the "efficiency ratio." This is the term now commonly used by engineers and is the one that will probably be used in the new Power Test Codes.

In the second place Mr. Taylor's method of calculating this factor consists of several steps, so that errors are more liable to be made than if a single calculation were used. This simple method is a rational development of the definition offered in the first paragraph of this letter.

$$\text{Efficiency Ratio referred to indicated horsepower (or brake or electrical horsepower.)} = \frac{2{,}545}{W\,(H_1 - H_2)}$$

where

W = Pounds of steam actually used per indicated horsepower-hour (or brake or electrical horsepower-hour as the case may be);

H_1 = Total heat per pound of steam at initial conditions before the throttle valve;

H_2 = Total heat per pound of steam after expansion at constant entropy to final exhaust pressure.

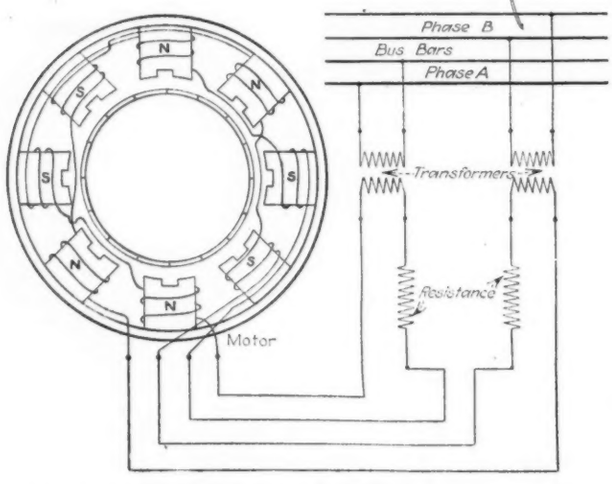
It is important that the basis on which the "efficiency ratio" is calculated, should be always specifically stated. That is, it should be stated whether the value refers to the "efficiency ratio referred to indicated horsepower" or to brake horsepower. Much confusion is caused by such a bare statement as "Efficiency Ratio = 70 per cent." One cannot judge whether this refers to indicated or to brake horsepower. The new Power Test Code of the A. S. M. E. will clarify many of these definitions and terms.

A. G. CHRISTIE.

Baltimore, Md.

A Phase-Rotation Indicator

Upon installing a two-phase alternator for operation in parallel with a similar machine, it was desired to know its "phase rotation" before permanent connections were made. Not having any polyphase motors at hand, an indicator was made from an old discarded single-phase 110-volt 8-pole 60-cycle fan motor, the poles of which had shading coils. By removing the shading coils and dividing the field winding into two groups of four poles each two independent phases were obtained, thus making a 4-pole two-phase machine as shown in the figure. To prevent any possible excessive current flow when the motor was connected to the circuit, a resistance was improvised from an old flat-iron element.



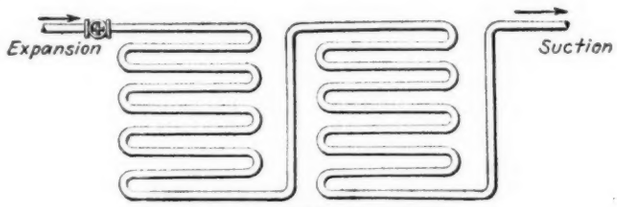
SCHEMATIC DIAGRAM OF PHASE-ROTATION INDICATOR

The fact that the number of poles was halved and the speed doubled by the new connection was of no consequence, since the rotor could stand the increased speed without harm and the machine would be in circuit only long enough for an indication. Two potential transformers were connected to the busbars and to the motor through the resistance, as shown. The rotation was noted when the busses were connected to the original machine, and then this unit was cut off and the new machine put on the busses and the phase rotation noted. If it proved to be the same as before, all connections could be made permanent, otherwise one phase would have to be reversed before doing so. This has proved to be a very handy device and may be of interest to other *Power* readers having such a motor on hand.

HENRY MULFORD, Chief Elec.,
Patchogue, N. Y. Patchogue Electric Light Co.

Connection of Cooling Coils

I have a twenty-ton compressor pulling an ice-cream hardening room on the second floor, a brine tank in the basement and another brine tank in the milkroom on the first floor. The hardening-room temperature is anything below zero F.; the milkroom is at a temperature of 40 to 50 deg. F. The milkroom brine is kept at anything below zero F. The ice-cream freezer brine in the cellar is kept at from zero to 2 deg. above. We also have an eight-ton machine. At night we run the larger unit on the ice-cream brine and the hardening room and the smaller unit on the milkroom and the milk-cooler brine.



COILS AS NOW CONNECTED

If the expansion cocks on the hardening room are more than barely cracked, we get a freeze-back and get it quick. The coils all lie on racks and the ice-cream cans sit on these coils. The back pressure is 15 lb. gage; the condenser pressure is 120 lb. gage.

We are never able to see ammonia in the receiver glass. The receiver is horizontal and placed under the condenser, which has two stands. In the ice-cream hardening room we can hear a sound like water surging in the coils. I believe it is ammonia, because I can pump down to zero and in five minutes after stopping have from 5 to 15 lb. gage again.

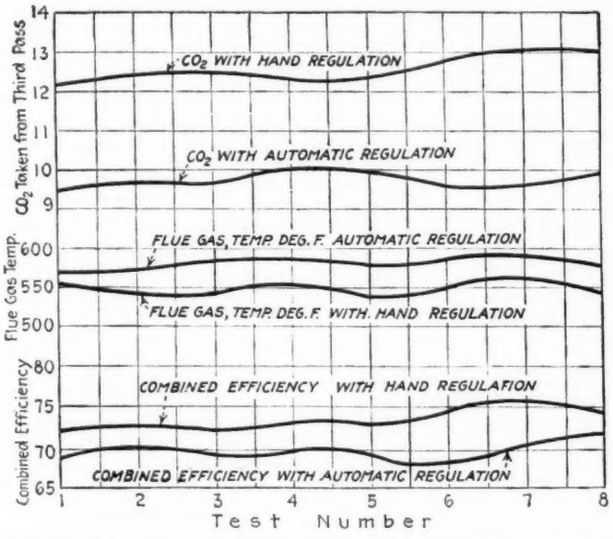
There are three hardening-room expansion cocks and two vestibule cocks. If all five are cracked ever so little, we get a freeze-back. The compressor is double-acting. If we work the big machine on the milkroom brine tank as well as on the ice-cream brine and hardening room, we get the same results and the milkroom brine warms up. All milkroom coils have a suction connection at the bottom and an expansion connection at top. All are short coils connected as shown in the sketch.

I advocate long coils with suction connection at the top and the expansion connection at the bottom. I have, in eight hours, pumped down 12 deg. F. on the ice-cream hardening room with the gage nearly zero.

Syracuse, N. Y. R. G. SUMMERS.

Automatic Regulation for Underfeed Stokers

Operating underfeed stokers, controlled by an automatic device to keep the steam pressure at a certain point, is a subject that should be given serious thought by any engineer who is contemplating installing them, because there should be taken into consideration various factors that will or will not permit of satisfactory operation. One of the most serious problems is to get a regulator to operate so that it will slowly open and close the control valve that regulates the stoker turbine or engine speed. Most regulators have a tendency to operate quickly with a variation of steam pressure, and of course this operates the valve lever quickly, with the result that the turbine is continually operating between two extremes, high and low speed, and in most cases the valves permit the steam to flow too fast to the turbine, quickly bringing it up to full speed. This is detrimental


CO_2 Taken from Third Pass
CO_2 WITH HAND REGULATION
CO_2 WITH AUTOMATIC REGULATION
Flue Gas Temp.
FLUE GAS, TEMP. DEG. F. AUTOMATIC REGULATION
FLUE GAS, TEMP. DEG. F. WITH HAND REGULATION
Combined Efficiency
COMBINED EFFICIENCY WITH HAND REGULATION
COMBINED EFFICIENCY WITH AUTOMATIC REGULATION
Test Number

CURVES SHOWING RESULTS OBTAINED WITH HAND AND AUTOMATIC REGULATION

to the turbine and also has a decided effect on the fuel beds of the stokers.

Suppose the working pressure is 150 lb. and the regulator is set to operate at this point. The speed range of the fan and turbine is from 500 to 2,000 r.p.m. When the steam pressure is at 150 lb. the fan is running at 500 r.p.m., but if it drops to 145 lb. the fan speed will suddenly change to 2,000 r.p.m. and jump the air pressure, say, from 2 in. to 6 in. in the short space of from five to ten seconds. Then, perhaps after five minutes' operation at high speed, the steam would be back at 150 lb. and the air pressure would then change from 6 in. back to 2 in. as suddenly as it came. This kind of operation certainly decreases the efficiency of the stokers, as one of the things most essential to their successful operation is to maintain the proper ratio between the coal and air.

Different grades of coal require different amounts of air; and supposing you have a light fuel bed on one stoker and a heavy fuel bed on another and the air pressure suddenly increases from 2 in. to 6 in., what is going to happen to the fuel beds of these stokers? The heavy fuel bed will not be affected very much, but if you will look at the fire through blue glasses, you will notice large airholes in various parts of the fuel bed. The light fuel bed will be in a very bad condition, because of not having sufficient coal on the tuyeres to withstand a higher air pressure.

Automatic regulation makes nice-looking steam charts and makes it easy for the firemen, but it surely is hard on the coal pile. From tests that I have run on various kinds of fuel, both with automatic and with hand regulation, I am convinced that where good firemen are available automatic regulation will surely show a decrease in efficiency, varying in some cases from 3 to 7 per cent.

The accompanying curves are of various efficiencies, CO_2 and flue-gas temperature averages taken on tests that I have run, and I believe that these results prove my statement to be true.

In most cases with automatic regulation the flue damper must be kept in the wide open position because, when the fan is operating at full speed, it requires the damper to be in that position in order to take care of the increased volume of flue gases, otherwise a pressure is created in the furnace. This results in an increased gas velocity and greater loss in flue gases, as it is impossible to carry a low suction in the furnace when the damper is wide open, and therefore the flue temperature is increased considerably.

It will be noticed that when operating the boilers at the same percentage of rating, there is an increase, when using automatic regulation, of from 20 to 40 deg. F. in the flue-gas temperature, over hand regulation. This loss can be cut down if the firemen have differential draft gages to control the suction over the fire and regulate their flue dampers to maintain a certain low draft suction over the fire at all times. This is almost impossible to do in forced-draft stokers equipped with automatic regulation, because one has to be continually changing the boiler damper position to take care of the increased or decreased volume of gases caused by the various fan speeds due to the regulator control. Therefore, it would seem that where automatic fan control is used, it is important that an automatic control system be used to operate the boiler dampers.

In most of the plants using automatic regulation, the regulators and valves are not set and connected up to get the best results. The steam line to the diaphragm of the regulator should never be connected to an auxiliary steam line or to a header where the wiredrawing of steam occurs, but it should be so connected that the true boiler pressure only will effect the movement of the regulator. The water pipe, which furnishes the water pressure to operate the piston of the regulator, should have a valve close to the regulator, and this valve should be opened just enough to allow the water to reach the cylinder slowly, so that it will not act on the piston too quickly; it will therefore have a tendency to operate the turbine or engine balance valve much slower.

If the regulator then operates the balance valve too quickly, lengthen the balance-valve lever to about thirty inches and drill six holes in the lever about one inch apart and set the connecting chain on rod to the regulator in the hole where the best results are obtained. In all cases where I have experimented with automatic regulation, I have found that if these suggestions are carried out, it is possible to get very near ideal operating conditions when operating in conjunction with a good balanced damper-control system to control the draft over the fire automatically with the various air pressures used under the fuel bed. This is absolutely necessary where economy is desired, as it is almost

impossible to get firemen to set the boiler dampers by hand when the air pressure changes often, as with automatic fan control.

From years of experience with underfeed stokers, I am firmly of the opinion that, from an economy, performance and operating standpoint, it is not good engineering to use automatic control for the fans unless the boiler dampers are also controlled automatically to operate in conjunction with each other. Therefore it would seem that it is better to control the stoker and boiler equipment by hand, rather than to have inferior automatic regulation.

D. C. HESS.

Lester, Pa.

Heater and Feed-Water Control

I once accepted a position as engineer at a small electric-light plant where they had had a great deal of trouble—in fact, so much that the people were disgusted and were about to cancel the contract and franchise, claiming that the machinery was no good. The equipment included an 80-hp. high-speed engine, one return-tubular boiler, one single-phase alternator, and an open feed-water heater with no control valve in the supply. This plant also pumped the city water.

I arrived at the plant one day at 11 a.m., made a survey of the machinery and listened to the complaints of several citizens and of the man in charge. At about 4 p.m. I started up with the engine pounding in the crank, crosshead and main bearings; the alternator seemed all right with the exception of a small spark at the rectifying commutator. I soon observed that I was not getting hot water from the heater, and about 5 o'clock I saw that the water in the gage glass was milky. It was blown out, but still it was the same, and by this time the spark on the alternator had grown so big that I did not need a light in the engine room. In fact, it got so big that I had to shut down. I reset the brushes and started again. This did little good, but I managed to get by until 12 o'clock, when I pulled the fire under the boiler.

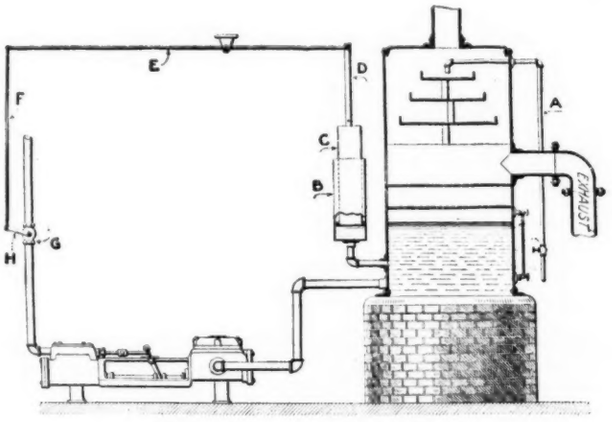
The next morning I reported to the manager and asked for two men. When we opened the boiler, we found mud eight inches deep in the back end and about one inch in the front. Why the boiler did not burn is a mystery to me. We took some pieces of chain and went over the tubes as best we could with the time we had, and I want to say that there was a difference in the firing of the boiler.

While one of the men was getting up steam, the other and myself went after the alternator. After examining the commutator carefully, I found that someone had had it off. We took a sandstone, some sandpaper and a file and dressed it down as soon as we got enough steam to revolve it. It acted about the same as it did the night before, so the next day I made a water rheostat and turned the commutator around on the shaft $\frac{1}{4}$ in., put 20 amperes on the machine and it sparked worse than ever. We shut down, turned it back $\frac{1}{4}$ in. and it did so much better with the same load that we shut down again and turned the commutator back some more and put on the load. Our fireworks had disappeared, showing that the commutator had been out of step with the polepieces.

The next day we went after the engine. The bearings were worn down on the brass, so we rebabbitted them and took about $\frac{1}{8}$ in. of liners out of the main bearings. Upon starting up, the engine ran fine; it seemed as though we were shut down when the plant was running, there was so much difference.

The heater was next opened, and it was found that the water went in at the bottom and out at the bottom, although there was an opening at the top for the water to enter. I later learned that the water got so hot that the pump would not handle it, so the engineer removed the pans and threw them on the junk pile in the rear of the lot and changed the water inlet to the bottom of the heater. This heater was set about one foot off the ground and the pump 18 inches.

There was but one thing to do and that was to raise the heater. On investigating we found that we could raise it five feet, so we procured the service of a brickmason, and by starting at 1 a. m. the heater was in place and connected up at 1 p. m. I gathered up the discarded heater pans and screens, which were still on the scrap pile as luck would have it, put them in place and started up the engine. We got hot water but the pump would not work. I removed the top of



HOME-MADE PUMP CONTROL

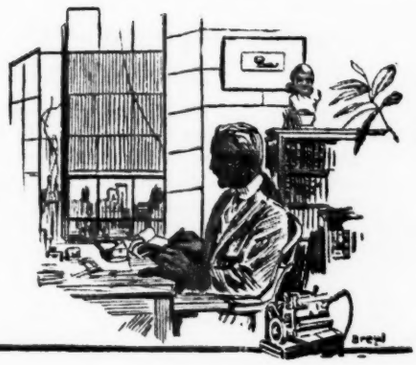
the water end and, on turning on the water, found that the springs on the suction valves were too stiff. I took them out, stretched them and cut off two turns, then replaced them, and on turning on the water, the pump cylinders were flooded. My trouble was ended so far as the pump was concerned.

The next thing was to get a regulator to govern the water level in the heater. How this was accomplished is shown by the accompanying illustration. Water enters at the top of the heater through the supply pipe *A*, flows over the pans and is heated by the exhaust steam which enters at a point below the pans. The water level is controlled by a galvanized-iron external float, made by the local tinner. The outside tank *B* is 10 x 20 in., and the inside one, *C*, is 8 x 20 in. It will be seen that as the water rises in the heater the float *C* rises, which carries a system of levers *D*, *E* and *F*, which are connected to the throttle valve *G* of the feed pump through the lever *H*. It will be apparent that the faster the water rises in the heater the faster the pump will run, and instead of regulating the supply to the boiler from the feed pump it is regulated from the water tower, not shown, at the valve in the pipe *A*.

After these changes were made, the plant ran like a new one; the people were much pleased and were convinced that the plant was not at fault after all, but that it was all up to the man who ran it.

East St. Louis, Ill. E. LITTLEFIELD.

INQUIRIES OF GENERAL INTEREST



Speed of Governor with Increase of Engine Speed—When an engine is speeded up, does the governor run any faster? M. F.

When speeding up is accomplished by a change in size of the driving pulleys or gear wheels, the governor makes the same speed as before, but if speeding up is accomplished by changing the governor weights or springs without changing the governor drive, then there is necessarily the same percentage of increase of the governor speed as of the engine.

Indicator Diagrams from Compound Engines—For the purpose of considering the valve setting of a compound engine, is it admissible to rely upon indicator diagrams of one cylinder taken at a different time from diagrams taken from the other cylinder? H. R. J.

The diagrams should be taken simultaneously, or at least so nearly at the same time as to insure the same conditions of load, engine speed, initial pressure, points of relative cutting-off and same back pressure. Otherwise the actual distribution of steam is largely conjectural, for the diagrams are not truthfully representative of relative performances of the cylinders.

Selection of Most Economical Degree of Superheat—In designing a new turbine station, how is the most economical degree of superheat arrived at? P. A. Y.

There generally will be saving of 2 to 4 per cent in the cost of fuel for each 100 degrees of superheat of steam at 150 lb. gage pressure. The use of a high degree of superheat is a matter of first cost and cost of maintenance against the price of fuel, depending also on the type of turbine, the load factor, the size of the units and the nature of the service as regards severe and frequent variations in the load, also having in mind the practical operation of suitable superheaters, steam piping, valves, pumps and auxiliary machinery.

Computing Indicator Diagrams Separately—In computing the indicated horsepower shown by indicator diagrams from a double acting engine, should the power be figured separately for the two ends of the cylinder, or may the net piston areas and mean effective pressures for the two ends be averaged? R. B.

For close computations, the power developed in each end of the cylinder should be computed separately as two single-acting engines, taking the sum as the total power indicated. When the values of net piston area and mean effective pressures are averaged, the calculation generally will result in a close enough approximation for most practical purposes, provided the mean effective pressures are nearly the same.

Air Chamber for Boiler-Feed Pump—What should be the size and shape of an air chamber to go on a boiler-feed pump? R. S. T.

The air chamber may be made of a large size of pipe capped at the upper end or may be of cast iron, made cylindrical or pear-shaped, the latter for greater strength of casting. The shape is immaterial so long as the vessel is strong enough to withstand the water pressure with safety and is large enough. It should have a capacity of at least six times the volume of displacement of the water cylinders, and greater volume will give smoother operation. The air chamber should be provided with a pet-cock near its lower end and another at the top for occasionally draining off the water and refilling air.

Exhaust Valves Must Not Have Lap for Compression—For obtaining compression on a single-eccentric Corliss engine, why is not lap given to the exhaust valves? M. F. S.

If compression is obtained by giving lap to an exhaust valve, thus causing it to close the exhaust port before the piston reaches the end of the stroke, it would also make the valve later in opening and the steam would not be released at exhaust until after the piston had completed its stroke. Hence the proper method of obtaining compression is to advance the eccentric beyond the 90-degree position and thereby obtain earlier release and earlier compression. Then to avoid excessive lead, that is, to hold the steam valve closed during the period of compression or until it is desirable to have the live steam admitted, it becomes necessary to give lap to the steam valve.

Operation of Reciprocating and Centrifugal Pumps in Parallel—Can a centrifugal and a reciprocating pump be operated in parallel for boiler feeding? J. K.

When a centrifugal discharge is connected into a feed line through a Y-branch, it can be operated in conjunction with a reciprocating pump discharging into the same feed line provided the reciprocating pump is fitted with an air chamber that prevents pulsation of the discharge and is not operated fast enough to maintain a feed-pipe pressure higher than the pressure that can be built up by the centrifugal. As the action of the reciprocating pump will be positive, the delivery by the centrifugal will not be parallel in the sense of bearing a constant ratio, but will be the additional flow that can take place through the check valve and the feed-pipe connections at the highest pressure that can be built up by the centrifugal.

Greater Efficiency of Exhaust Steam for Heating—What is the reason for exhaust steam heating up a building quicker than live steam? W. B.

Exhaust steam usually is wetter, containing more water swept along with the steam at the same temperature than in case of steam of quality generally discharged by a low-pressure heating boiler, or that is made drier when discharged through a pressure-reducing valve. Exhaust steam thereby contains rather more heat units per cubic foot, and the conduction of heat to pipes, coils and radiators is more rapid with wet steam than with dry steam. But where the steam supplied is of the same actual quality and pressure, there is no difference in the time required for heating up a building by live or exhaust steam, and the greater efficiency commonly attributed to exhaust steam is generally due to a more liberal supply and maintenance of actually higher pressure and temperature of the steam.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses —Editor.]

German Development of the Gas Turbine Since 1914*

The older readers of *Power* will remember the work of Hans Holzwarth on the gas turbine. In the issue of Feb. 6, 1912, was described a unit of 1,000 hp. which he had completed and tested at Mannheim. The work was done under the patronage of Thyssen & Co., and since the war it has been resumed at its establishment at Rhur. The new turbine is built along the lines of that built at Mannheim.

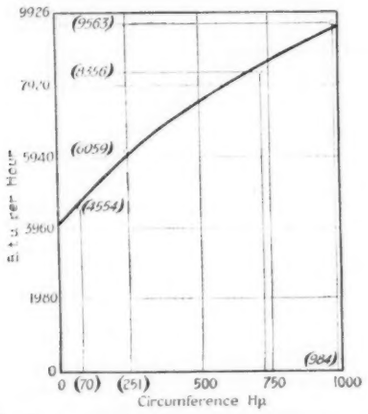


FIG. 1. TOTAL HEAT SUPPLIED COMPARED WITH POWER AT THE WHEEL

The objects sought by the inventor in the later design are:

1. Increase of the load and explosion pressure.
2. The development of a bucket and a method of fastening it to conform with the increased power conditions.
3. Shortening of the expansion period.
4. Testing of the most appropriate bucket form for continuous use.
5. Development of the most efficient type of nozzle.
6. Development of a nozzle valve suitable for carrying the higher load pressure and of a larger cross-sectional area.

It is the hope of the inventor to create a simple gas turbine which it will be possible to build in large quantities and the first cost of which will be smaller than that of a steam turbine with the necessary boiler equipment or of an internal-combustion engine, and whose total economy will be greater.

How far this object has been accomplished the following will show:

1. By increasing explosion pressure the work per cubic meter of cylinder area and the thermal power efficiency was increased.

In continuous running tests, the average explosion pressure was raised from 12 to 14 atmos. abs., as compared with 5 to 6 atmos. abs. of the Mannheim turbine.

2. The shorter the explosion period the less heat will be lost to the cylinder walls and therefore more heat will be changed into mechanical energy and the efficiency will be materially increased.

At present the time of expansion in the gas turbine is approximately 0.1 sec. In a large gas engine running at 90 r.p.m., the expansion period is about one-third of a second. Fundamentally, there is nothing to prevent a further decrease in the expansion time of the gas turbine. To do this it is necessary to increase the cross-section of the nozzles which also increases the length of the turbine blades and the flow resistances.

3. With the decrease of the expansion time the bucket pressure is increased. In the steam turbine this bucket pressure works uniformly in a comparatively small passage. In the explosion gas turbine the jet works intermittently, by short impulses in the form of a blow. Under those conditions the familiar type of bucket form is entirely unfit. A bucket is said to have been already developed which is equal to the severe requirements of continuous use. This form corrects the turning action due to the jet and provides an ample margin of safety against defects in material and workmanship. The base of the comparatively long bucket fits into a groove machined in the face of the wheel and fastened by a key driven in a slot in the bucket, which expands it in the groove. The head, body and root of the blade are made of one solid piece like the blading of a De Laval turbine.

After a number of tests and experiments soft electro-iron made in the steel works of the Thyssen Co., after proper heat treatment, proved adequate for gas-turbine service. Blades of this material stood up much better than those of harder steel or steel alloys.

De Laval nozzles and nozzles with parallel walls were tested with the result that the former type was found most suitable. Increased explosion pressure called for a further development of the nozzle valve. The object of the valve is to close the explosion chamber gastight until the ignition occurs, and to leave a large opening for expansion, quickly allowing gases to pass to the nozzle without throttling. These conditions were successfully met, and the charging and explosion pressures were increased so that ignitions are complete.

In December, 1919, a number of tests with coke-oven gas were made, as shown in Fig. 1, on the turbine built by Messrs. Thyssen & Co. The amount of gas was calculated according to the swivel baffle method. The heat value of the gas was determined by the Junkers calorimeter and found to be, on an average, 3,860 calories per cubic meter (Zero deg. C., 760 millimeters mercury). An electric load

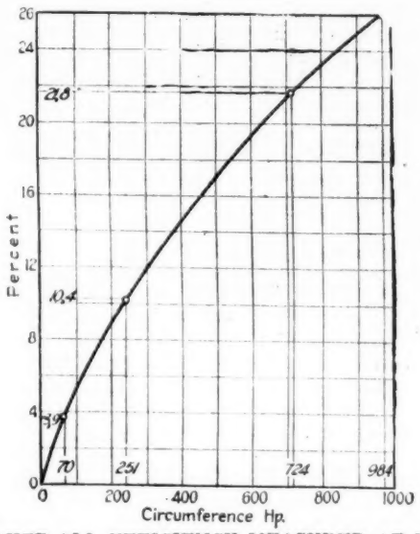


FIG. 2. OVER-ALL EFFICIENCY MEASURED AT THE CIRCUMFERENCE OF THE WHEEL DEPENDING UPON THE OUTPUT TRANSMITTED TO THE WHEEL

was carried on a water resistance. During the whole series of tests all the ten chambers were working and at lighter load none of the chambers were switched off. In regular operation it is intended to switch off some of the chambers by means of the governors, thereby materially improving the efficiency under partial load. The test lasted about one hour.

Test No.	1	2	3	4
Quantity of gas at 0 deg. C., 760 mm. mercury cu.m. per hour	300	400	550	660
Quantity of heat admitted kg. calories per hour	1,150,000	1,530,000	2,110,000	2,415,000
Output transmitted to the wheel (useful hp.)	70	251	724	984
Heat consumption				
Kg. calories per hp.-hr.	16,430	6,090	2,915	2,450
Efficiency at the circumference of the wheel, per cent	3.9	10.4	21.8	26

Figs. 1 and 2 have been plotted, the amount of heat admitted per hour and the efficiency at the circumference

*Abstract from the Zeitschrift Des Vereines Deutscher Ingenieure.

dependent upon the output transmitted to the wheel being expressed in circumferential horsepower.

The work necessary for compressing air and gas amounted to about 5.7 per cent of the waste heat. If the efficiency of the compressors is taken to be 70 per cent, that of the exhaust steam turbine 18 per cent, and that of utilization of the waste heat 60 per cent, a total efficiency

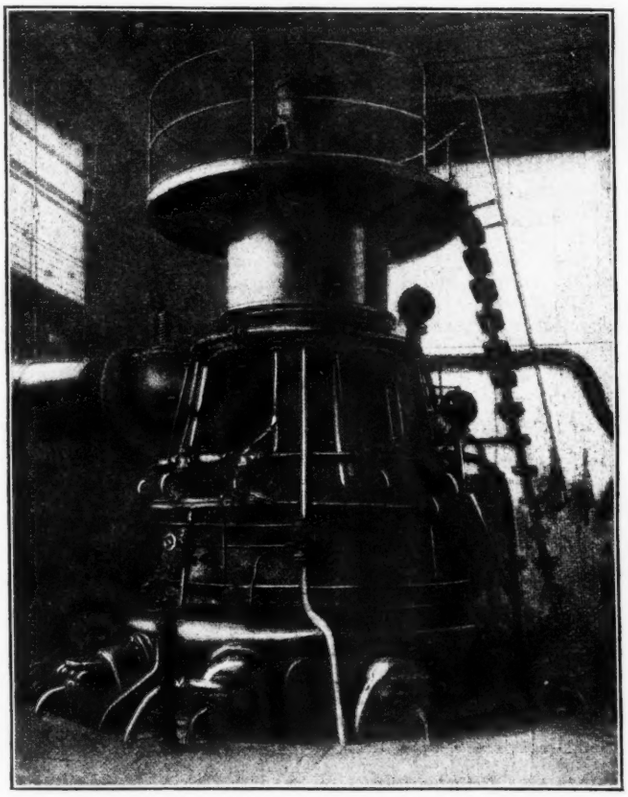


FIG. 3. ONE THOUSAND HORSEPOWER GAS TURBINE

for the waste-heat plant and compressor sets of $0.7 \times 0.18 \times 0.6 = 7.6$ per cent may be obtained.

With plants of this description it is easily possible to satisfy the power consumption of the blower out of the waste gas heat.

The Federal Water Power Commission Receives Applications for Permits

A number of applications for permits and licenses for the utilization of water power and the construction of power plants have been filed with the Federal Water Power Commission under the provisions of the Water Power Act passed by Congress at the last session.

Each application will be considered on its merits, it is announced, and the prior date of an application for a permit to a power site will be given cognizance only when all other factors are equal. The list of applicants, with the proposed power sites, is as follows:

Alabama Power Co., preliminary permit for hydro-electric plant on the Coosa River in Alabama, below Government Lock No. 2; Speel River Power Co., San Francisco, preliminary permit for power project to be located in the Tongass National Forest in Alaska; C. A. Heberlein, Prescott, Ariz., preliminary permit for project in Cataract Canyon, Coconino County, Arizona; Dixie Power Co., Chicago, Ill., preliminary permit to construct a dam across White River, near Potter, Baxter County, Ark.

Far West—Pitt River Power Company, San Francisco, preliminary permit for power project on Pitt River, California; R. W. Hawley, San Francisco, preliminary permit to develop project on Silver Creek and its branches in Eldorado County, Cal.; Beckman & Linden Corp., San Francisco, preliminary permit for project on Colorado River in Arizona and California; G. W. Spoerry, Bonners Ferry, Idaho, preliminary permit for project on Moyie Falls on Moyie River, Idaho; Utah Power and Light Co., preliminary permit for Soad Point, Lava, Narrows, and Mink power sites on Bear River, Idaho; Idaho Power Co., preliminary permit for Upper Salmon Falls project, Snake River, Idaho; Idaho Power Co., preliminary permit for Twin Falls Project on Snake River, Idaho.

Mid-West—J. D. Markham, A. Kelsey and J. F. Druar, St. Paul, Minn., preliminary permit for Kelsey-Markham-Druar Dam Site on St. Croix River, between Minnesota and Wisconsin; St. Cloud Water Power Co., preliminary permit to construct dam across Mississippi River, in Sherburne County, Minn.; W. R. Banks, preliminary permit for project on Osage River between Warsaw and Tuscumbia, Mo., and Niagara River between towns of Hahatonka and mouth of Little Niagara River; Western Tie and Timber Co., St. Louis, Mo., preliminary permit for power project on Current River, Mo., in Ripley, Carter and Shannon counties; Rocky Mountain Power Co., Butte, Mont., preliminary permit for hydro-electric project on Flathead River; The Canada Syndicate, Ltd., of Montreal, Canada, and Duncan, Young & Co., New York, preliminary permit to develop water power in Delaware River above the town of Belvidere, N. J.; C. P. Chenault, Tulsa, Okla., preliminary permit for power project on the Arkansas River at a point commonly known as Ox Bow Bend, Northwest of Tulsa, Okla.; Crown Willamette Paper Co., Portland, Ore., license for development at falls of Willamette River, West Linn, Oregon.

New York State—City of Buffalo, preliminary permit for project on Niagara River; Henry Ford and Son, license for project on Green Island, Government Dam at Troy, New York, Hudson River; Louisville Power Co., preliminary permit for project on St. Lawrence River, from the west end of Croil Island (sometimes called Baxter's Island, or Upper Long Sault Island) westerly up the St. Lawrence River to the easterly end of Gooseneck Island; Hydraulic Race Co., Lockport, N. Y., preliminary permit for power project on Niagara River, N. Y.; Paul T. Brady, New York City, preliminary permit for dam across Delaware River at a point between the village of Barryville on the New York side and the village of Shohola on the Pennsylvania side of the river; Lower Niagara River Power and Water Supply Co., preliminary permit for project located at point about 500 feet south of Michigan Central Railroad bridge, which point is about midway between Cleveland Ave. and Niagara Ave., in the City of Niagara Falls, water to be returned to Niagara River at a point in town of Lewiston, Niagara County; Niagara County Irrigation and Water Supply Co., preliminary permit for project on Niagara River, N. Y.; Niagara Falls Power Co., preliminary permit to divert water from Niagara River above the Falls, under the provisions of the treaty between the United States and Great Britain, proclaimed May 13, 1910; Niagara, Lockport & Ontario Power Co., preliminary permit for diversion and use of water for hydro-electric power purposes from above the Falls at Niagara; St. Lawrence Transmission Co., Potsdam, N. Y. preliminary permit for project on St. Lawrence River in vicinity of Long Sault Rapids, St. Lawrence County, N. Y.; Thomson & Porter, Buffalo, N. Y., preliminary permit for project on Niagara River and for hydro-electric plant in Niagara Gorge; Niagara Gorge Power Co., Buffalo, N. Y., preliminary permit for diversion of water from Niagara Falls; Roanoke River Development Co., Richmond, Va., preliminary permit for project on Roanoke River in Mecklenburg County, Virginia, between Bugg's Island and the town of Clarkesville.

Northwest—Washington Irrigation and Development Co., preliminary permit for project on Priest Rapids, Columbia, River, Wash.; Alex Polson, M. E. Reed and W. H. Abel, Montesano, Wash., preliminary permit for project at headwaters of Wynooche River in Olympic National Forest, Washington and northeastern part of Gray's Harbor; Northwestern Power and Manufacturing Co., Seattle, Wash., preliminary permit for project on Lake Crescent in Clallam

County, Elwha River, in Washington; Hugh. L. Cooper, New York City, preliminary permit for project on Clarks Fork of the Columbia River, Wash.; Sound Power Co., H. O. Pond, president, New York City, preliminary permit for project on Sultan River and Olney Creek, in Snohomish County, Wash., and to use waters of Solduc River, Crescent Lake and Lyre River, in Clallam County, Wash.

Applications for preliminary permit or license were filed with the Federal Power Commission during the week ended Aug. 28, as follows:

Tongass Alaska Pulp and Paper Co., by M. M. Lyter, attorney, Alaska Building, Seattle, Wash., application for preliminary permit for utilization of Fish Creek, Swan Creek, Big Lake, Mirror Lake and Swan Lake for power purposes and for authority to construct power plants, pulp and paper mills on the southeast shore of Carroll Inlet in southeastern Alaska.

The Cove Co., Ocala, Fla., J. D. Robertson, secretary, application for preliminary permit to erect dam and power house on Withlachoochee River above Stokes Ferry for the purpose of generating hydro-electric power.

The State of Illinois, by Governor Frank O. Lowden, Springfield, application for license for power development on Des Plaines and Illinois Rivers.

W. A. Dromgold, York, Pa., application for preliminary permit to erect dam on or across the Susquehanna River at or near Cumberland below the mouth of Yellow Breeches, Pa.

Tri-State Power and Milling Co., of W. Va., Tri-State Power Co., of Virginia, O. L. Stearnes, president, Salem, Va., application for preliminary permit to erect dam and power house for hydro-electric purposes at a point below Anderson Falls, of New River in Summers County, W. Va.

Priest Rapids Irrigation District, by W. J. Kincaid, president, White Bluffs, Wash., application for preliminary permit to develop power in Priest Rapids of Columbia River.

Says Wage Increase Should Lower Price of Anthracite

That the anthracite coal operators increased their profits fifty cents a ton through the one dollar raise in the price of coal on April 1 in anticipation of the wage increase, was brought out by W. Jett Lauck, who was the consulting economist for the United Mine Workers, in presenting the case of the miners to the Anthracite Coal Commission. The operators did not stop here, however. In many cases the increase was much greater. A leading Washington dealer quotes anthracite for domestic use at $15.50 per ton, an advance of $3.70 since May 1. In other cities the increase was even larger.

Mr. Lauck declared that the average advance in labor costs was 17 per cent as a result of the recent award by the wage commission, and as the labor cost of producing a ton of coal ranges from $2.71 to $3.10, the increased cost to the operators with the maximum figure as a basis would be 52.7 cents per ton. On the basis of a ninety million ton per year production, the operators have taken from the public more than $30,000,000 of which they are required to pay the miners only $15,000,000.

"Prospective increases in labor costs is the reason for these advances," said Mr. Lauck, "and since the operators' estimate of what that increase would be was fully double what it has actually proved to be, it is obvious that the price to the consumer should be reduced at least $1.85 per ton, on the basis of Washington price advances since May 1."

To Hold Water Power Convention

Representatives of all the states in the Union, manufacturers and producers of power, will meet in Washington, D. C., Oct. 7 and 8 at the convention of the Water Power League of America, called to discuss the new Federal Power Act and its relation to the laws of the several states and how best to bring about the benefits expected to result from it.

The convention is called that the state officials may come in contact with the members of the Federal Power Commission with a view of co-ordinating their efforts and that a workable program may be evolved which will bring the greatest benefit to the people of the country at large.

The convention will not attempt to settle any of the questions which have been disputed in the years past. It recognizes that the United States has now adopted a policy for water-power development and the day of debate is past. How to get immediate action will be the only question to be considered.

The farming interests of the country will be represented by a speaker from the National Grange who will tell what the farmer expects from the Federal Power Act. Such practical subjects as "Financing Under the Federal Power Act," "The Advantages of the Federal Power Act from the Standpoint of the Practical Developer and Operator," "Cooperation Between the Power Producer and Federal Power Commission," will be discussed by competent authorities and the Secretaries of War, Agriculture and the Navy will hold question and answer sessions at which information may be obtained direct from the fountain heads as to how their several departments are expected to function in the administration of the affairs of the Commission.

The convention will be an open one. Every manufacturer and person interested in the subject of development of the water resources of the country is invited to attend. All that will be necessary will be to notify the Water Power League of America, 116 Nassau St., New York City, and reservations at The Washington, where the convention will meet, will be made. The meeting is expected to prove one of the most important economic conferences which has been held in Washington in years.

Evanston Instructs Her School Engineers

Owing to the changed conditions in the fuel market necessitating the use of Illinois mine-run coal rather than Pocahontas or even hard coal, which some of the schools have been burning, the board of education of Evanston, Ill., decided that it would be well worth while to educate the janitors and engineers in the various school buildings in the proper methods of burning the new fuel.

Arrangements were made with Osborn Monnett, of Chicago, for a series of five lectures and inspection tours in which demonstrations were made and personal instructions given. The lectures covered combustion, storage and efficiency measures calculated to meet the conditions. The present high price of coal was an influencing factor, and in any event efficient smokeless combustion was desired, particularly as the schools for the most part are located in desirable residential sections.

Cannot Pass the Coal Increase on to Consumer

The Public Utilities Commission of the District of Columbia has cut short the effort of the Potomac Electric Power Co. to pass on to wholesale power users the cost of its coal. Commenting on this phase of the decision, the commission objected to the coal clause because there is less incentive to secure coal at the most advantageous price when it is known that the cost is passed automatically to the consumer. As the increase in the cost of coal affects all consumers, such an increase should be borne as nearly as possible by each class in its proper proportion.

The power company asked for various increases, but was allowed to advance its rates only one-half cent per kilowatt-hour. In addition it was permitted to abolish certain discounts and will receive more for street lighting.

The United States Department of Agriculture is producing gas by the destructive distillation of wheat, oat and rye straws. Although an automobile has been operated with the new combustible and it has been used for illuminating purposes and cooking, it is still in an experimental stage. Production tests are under way to determine the exact commercial value of the product.

Water-Power Commission Formulates Regulations

THE first ten of the water-power regulations have been finally approved. Some time necessarily must elapse before the regulations governing the financial features of the Act can be promulgated. The regulations approved, however, contain two of great importance: those referring to permits and licenses. Regulation 9, which covers permits, reads as follows:

A. Except as hereinafter provided, preliminary permits may be issued on the application of citizens, associations, corporations, states or municipalities desirous of obtaining licenses for the construction, maintenance or operation of dams, water conduits, reservoirs, power houses, transmission lines or other project works, necessary or convenient for the development and improvement of navigation, and for the development, transmission and utilization of power across, along, from or in any of the navigable waters of the United States, or upon any part of the public lands and reservations of the United States (including the territories), or for the purpose of utilizing the surplus water or water-power from any government dam.

B. Permits will be issued only for the purpose of enabling applicants to maintain their priorities while securing the data required for an application for license and will be for such periods, not exceeding a total of three years, as in the judgment of the Commission will be necessary for studying the proper location and design of the project; for making examinations, surveys, maps, plans, specifications and estimates; for conducting stream measurements; for sinking test pits or making borings to determine foundations for dams or other structures; for securing a market for the power to be developed; for making financial arrangements; or for any other purpose necessary or desirable in the preparation of application for license.

C. Permits will not be issued for projects already constructed; for transmission lines alone; for projects of a power capacity of less than 100 horsepower; for projects which, in the judgment of the Commission, do not come within the scope of its authority under the Act, or should be undertaken by the United States itself, or do not propose adequate schemes of development, or would interfere unreasonably with projects under permit, license or other authority theretofore granted; or for projects for which data sufficient for filing application for license are already available. Permits affecting any reservation will be issued only after a finding by the Commission that the proposed use will not interfere or be inconsistent with the purpose for which such reservation was created or acquired. Permits will not be issued until after the expiration of the publication period prescribed by the Act.

D. In acting upon applications for preliminary permits, and in determining preferences therefor, the Commission may, in its discretion, upon the request of any applicant or upon its own motion, hold hearings, order testimony to be taken by deposition, summon witnesses, or require the production of documentary evidence.

E. No charges will be made for permits, but permitees will be required, as a condition of maintenance of priority to perform such work and to make such studies and investigations, and such reports thereon, as in the judgment of the Commission may be necessary or desirable to enable both the applicant and the Commission to determine the feasibility, character and extent of development which is proposed or which should be undertaken, which requirements will be expressed in the permit.

F. Upon a satisfactory showing of reasons therefor the Commission may authorize permitees to perform such construction work as may be necessary to maintain water rights under state law, or as may be desirable in preparation for the construction of project works; but the granting of such authority shall not be deemed to have created any equities or to have established any rights beyond what would have been created or established had such authority not been given.

G. Permits will not be transferable and may be cancelled by order of the Commission for failure to comply with the conditions thereof.

H. Each preliminary permit shall set forth the conditions under which priority shall be maintained and a license issued, and shall also set forth the essential terms and conditions of such license.

Regulation 10, dealing with licenses, reads as follows:

A. Except as hereinafter provided, licenses may be issued either in accordance with the provisions of preliminary permits or upon direct application therefor by citizens, associations, corporations, states or municipalities, for the purpose of constructing, operating and maintaining dams, water conduits, reservoirs, power houses, transmission lines or other project works, necessary or convenient for the development and improvement of navigation, and for the development, transmission, and utilization of power across, along, from or in any of the navigable waters of the United States, or upon any part of the public lands and reservations of the United States (including the territories), or for the purpose of utilizing the surplus water or water power from any government dam.

B. Licenses will be issued for such periods, not exceeding fifty (50) years, as in the judgment of the Commission will, in each individual case, allow for the satisfactory development and operation of the project and protect the public interest, and shall remain in full force and effect for such periods unless surrendered or terminated as provided in these regulations or revoked as provided in the Act.

C. Licenses will not be issued for projects which, in the judgment of the Commission, do not come within the scope of its authority under the Act, or should be undertaken by the United States itself, or do not propose adequate schemes of development, or lack satisfactory showing of financial ability, or would interfere unreasonably with projects under permit, license, or other authority theretofore granted, or would be opposed to the public interest. No license affecting the navigable capacity of any navigable waters of the United States will be issued until the plans of the dam or other structures affecting navigation have been approved by the Chief of Engineers and the Secretary of War. Licenses within any reservation will be issued only after a finding by the Commission that the license will not interfere or be inconsistent with the purpose for which such reservation was created or acquired. Licenses will not be issued until after the expiration of the publication period prescribed by the Act.

D. Licenses may be altered only upon mutual agreement between the licensee and the Commission. Any such alteration shall be made a part of the license and a substitute for the provision altered, but no such alteration shall operate to alter or amend or in any way whatsoever be a waiver of any other part, condition or provision of the license.

E. Licenses may be surrendered only upon mutual agreement between the licensee and the Commission, and upon the fulfillment by the licensee of all obligations under the license, with respect to payment or otherwise, existing at the time of such agreement, and, if the project works authorized under the license are constructed in whole or in part, upon such conditions with respect to the disposition of such works as may be determined by the Commission.

F. Licenses may be terminated by written order of the Commission after such reasonable notice, not exceeding ninety (90) days, as the Commission may grant, if there is failure to commence actual construction of the project works within the time prescribed in the license, or as extended by the Commission. Under similar conditions and upon like notice the authority granted under a license may be terminated with respect to any project works or separable part thereof covered by the license, if there is failure to begin construction of such project works, or part thereof within the time prescribed in the license or as extended by the Commission; but no part of the project works shall be deemed separable for the purposes of this regulation unless so specified in the license.

G. Licenses may be revoked only through proceedings in equity instituted in the District Court of the United States for a district in which some part of the project is situated, and in the manner provided in the Act:

> (a) In case construction of the project works covered by the license, or of any specified part thereof, has been begun but not completed within the time prescribed in the license, or as extended by the Commission; or
>
> (b) In case the terms of the license are violated by the licensee.

Before the ten regulations were finally approved they were subjected to most careful scrutiny by outside interests and many of their suggestions are embodied in the regulations.

New Publications

THE McGRAW CENTRAL STATION DIRECTORY AND DATA BOOK FOR 1920. Published by the McGraw-Hill Co., Inc., New York City, 868 pages; 4½ x 8½ in.; price, $20.

This book is an invaluable guide and is complete in every way. It contains central-station data arranged by states and cities; statistics of the central-station industry; status of domestic and commercial electric service; a list of towns with a population under 1,000 getting current elsewhere; state commissions having jurisdiction over electric light and power utilities and an index to central stations whose names do not indicate their location.

NEW YORK STATE BOILER CODE "The New York State Boiler Code," as recently amended and readopted, is now ready for distribution. The rules relate to the construction, installation, inspection, and maintenance of steam boilers and should prove of value to all manufacturers of boilers, jobbers, and in repair shops. A copy of these rules can be obtained by application to the State of New York Department of Labor, State Industrial Commission, Capitol, Albany.

ONTARIO HYDRO-ELECTRIC POWER COMMISSION REPORT

The Twelfth Annual Report of the Hydro-Electric Power Commission of the Province of Ontario for the year ended Oct. 31, 1919, is now ready for distribution. The report, which contains 243 pages, is a complete account of the work performed by the commission during the year. The text contains a description of the great increase in the use of power during the war and of the sudden slump following the signing of the armistice. Operating and maintenance costs of various plants are given, as well as notes on operation, load curves, etc. The book is concluded with a statement of total plant cost, investment, operating reports, depreciation charges, horsepower, peak taken in December, 1919, street-lighting installations, cost of power and selling rates.

Personals

Harry T. Harmon is now transmission engineer for the Hyatt Roller Bearing Division, General Motors Corporation, Newark, N. J.

Gerardo Immediato has been appointed professor in charge of machine and power-plant design at the Polytechnic Institute of Brooklyn.

A. W. Huseby, formerly chief engineer, Armour Mechanical Co., U. S. Yards, Chicago, Ill., is now in the master mechanic's office of Morris & Co. Chicago.

J. C. Parmely, who has been connected with the Okmulgee Ice and Light Co. of Okmulgee, Okla., is now with the Milwaukee Electric Railway and Light Co.

B. B. Williams, at a meeting of the directors of The C. & G. Cooper Co. of Mt. Vernon, Ohio, was elected president of the company to succeed D. B. Kirk, deceased.

Elias Schlank, formerly assistant mechanical superintendent for Julius Kayser Co., Brooklyn, N. Y., is now located in Newark, N. J., as a consultant factory engineer.

D. H. MacDougall, of the Toronto Power Company, Toronto, Canada, has just been appointed Chairman of the Public Relations Section of the Canadian Division of the N. E. L. A.

A. A. Potter has resigned his position as dean of engineering at the Kansas State Agricultural College to accept a similar position at Purdue University, Lafayette, Ind.

Walter C. Lange has resigned his position as engineer with the Hammel Oil Burning Equipment Co. and now holds a similar position with The Howard Moore Co., of New York City.

Fred F. Bahnson, formerly engineer for the Normalair Co., Winston-Salem, N. C., is now vice president and engineer of the Bahnson Humidifier Co., Salem Station, Winston-Salem, N. C.

Reginald Pelham Bolton, consulting engineer, announces that James A. McHollan is now associated with him as vice president of The R. P. Bolton Co., 116 East 19th St., New York City.

Paul De Leon, consulting engineer, who for some years was in business in the East, has opened an office at Manitowoc, Wis. His work will consist of general engineering and utilities engineering.

J. H. Figee has severed his connection as engineer with the Steere Engineering Company, of Detroit, and is now affiliated with the Ford Motor Company, in the Rouge plant at Dearborn, Mich.

Louis C. Seabright has severed his connections with the Stanton Heater Co. of Martins Ferry, Ohio, and is now serving in the capacity of engineer for Warren Webster & Co., 706 Rose Building, Cleveland, Ohio.

E. A. Hitchcock, formerly vice president of the Bailey Meter Co., of Cleveland, Ohio, is returning to Ohio State University at Columbus, Ohio, where he spent several years. He has been appointed dean of the Engineering College.

Jay Carrol Wheeler, who has been engaged with the Kerr Turbine Co. as construction engineer for the last ten years, has resigned to become construction engineer for the C. H. Wheeler Manufacturing Co., of Philadelphia, Pa.

Dr. Alphonse Adler, for the past ten years professor in charge of machine and power-plant design at the Polytechnic Institute of Brooklyn, has resigned and will devote all his time to his practice as consulting engineer in power and industrial plant engineering, with an office in New York City.

I. A. Baum, formerly assistant general manager for the La Salle Engineering Co., of Chicago, Ill., will in the future have only an inactive interest in that company. He is now vice president of the American Rotary Engine Co., Grand Rapids, Wis.

W. N. Dickinson has been elected president of the New York Electrical Society to succeed Edwin B. Katte. Mr. Dickinson is a consulting engineer and has been associated with several elevator companies, principally the Otis Elevator Company. During the war he was engaged in war work at Washington.

Albert Ladd Colby has resigned as the representative of the American Society of Testing Materials, on Engineering Council. He will be succeeded by C. D. Young, vice president of the society and general supervisor of stores on the Pennsylvania System, Broad Street Station, Philadelphia.

W. E. Anderson and Ward Raymond, formerly chief engineers, of Phillipsburg, N. J., with the A. S. Cameron Steam Pump Works and the Ingersoll-Rand Co., respectively, are now associated with the Pennsylvania Pump and Compressor Co., of Easton, Pa., the former as chief engineer and the latter as vice president.

G. A. Sawin, service engineer with the Public Service Electric Co., Newark, N. J., has resigned to become assistant to manager of the supply department, Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa. In his new position Mr. Sawin will take care of the public-utility work of the supply department.

Timothy Healy, president of the National Brotherhood of Stationary Firemen, was tendered a testimonial banquet and bon-voyage reception at the Yorkville Casino, New York City, on Wednesday, Aug. 11. Mr. Healy has sailed for England to represent the American Federation of Labor at the British Trades Congress. There were over three hundred present, and many prominent speakers wished Mr. Healy godspeed. James P. Holland was the toastmaster.

F. W. Dean, formerly mill engineer and architect, of Boston, and for nearly three years in war work for the United States Shipping Board Emergency Fleet Corporation in charge of the steamship boiler department and testing of boilers, will resign his position to become effective Oct. 1, 1920. Mr. Dean will become associated with L. N. Wheelock and J. C. Bogue, now of the firm of the Wheelock-Bogue Co., 141 Milk St., Boston, under the firm name of Wheelock, Dean & Bogue, Inc., which organization will be the New England agent for the Erie City Iron Works, of Erie, Pa., and of several other companies.

Henry Kreisinger, formerly of U. S. Bureau of Mines, has been appointed as engineer of research of the Combustion Engineering Corporation. Mr. Kreisinger will conduct investigations for the Combustion Engineering Corporation of a similar nature to those that he conducted for the Government; and the results of his work will be available to the Government as well as to the clients of the Corporation. He will make his headquarters at the Bureau of Mines Station at Pittsburgh. The first problem which he will consider will be a thorough testing of the powdered-coal plant of the Bureau of Mines at Milwaukee, Wis.

Society Affairs

The National Association of Electrical Inspectors will hold its annual meeting at Philadelphia, Oct. 12 and 13.

The Electric Power Club wil hold its fall meeting at Hot Springs, Va., Nov. 15 to 18. Headquarters will be made at the Homestead Hotel.

The New York Section of the American Society of Refrigerating Engineers will hold its next regular meeting on Wednesday evening, Sept. 15, at the Machinery Club, 50 Church St. A fine program has been arranged in which W. S. Osborn, of the Texas Company, will deliver a paper on "Lubrication of Refrigerating Machinery." This will be accompanied with lantern slides showing technical data and curves.

The Indiana Electric Light Association will hold its annual convention at French Lick, Sept. 15 to 17. The first session will be opened with the president's address, followed by various committee reports. Sept. 16 will be featured as commercial section day. Addresses will be given on "Voluntary Versus Involuntary Co-operation," by William L. Goodwin, and "Central Stations and Contractors," by Samuel Adams Chase; paper on "Industrial Application of Electric Power-Factor Correction and Its Effect," by T. F. English, general manager of the Indiana General Service Co.; paper on "Reduced Operating Expenses Versus Increased Fixed Charges," by George A. Neal, Northern Indiana Gas and Electric Co. A round-table discussion will follow, the election of officers closing the program.

A Great Lakes Division of the N. E. L. A. was organized at a meeting of central station organization representatives from Michigan, Indiana, Illinois, and Wisconsin, held in Chicago, Aug. 27. Officers elected for the new division are: Chairman, W. C. Lounsbury, Superior (Wis.) Water, Light and Power Co.; vice-chairman, P. H. Palmer, Indiana Railways and Light Co., Kokomo; secretary-treasurer, R. V. Prather, Springfield, Ill. The following were appointed chairmen of the division sections formed: Public relations section, A. C. Marshall, Detroit Edison Co.; commercial section, J. G. Learned, Public Service Co. of Northern Ill., Chicago; technical section, G. E. Lewis, Detroit Edison Co., Ann Arbor, Mich.

The Association of Iron and Steel Electrical Engineers will hold its fourteenth annual convention at the Hotel Pennsylvania, New York City, Sept. 20 to 24. Among the papers to be read are: "Practical Education of Steel Mill Electricians," W. A. Cornwell; "Relation of Standardization in Electrical Equipment to Safety," Walter Greenwood; "Power Transmission for Industrial Plants," D. M. Petty; "Underground Transmission," A. L. Frerst; "Some Considerations in the Determination of Auxiliary Drives," Gordon Fox; "The Reversing Electric Mill Considered From the Standpoint of Tonnage," K. A. Pauly; "Report of Electrical Development Committee for 1920," E. S. Jefferies; "Centralized Turbine Generating Stations for Steel Mills," T. E. Keating; "Current Limit Reactance," R. H. Keil; "Report of Electric Furnace Committee for 1920," E. T. Moore, chairman, and "Standardization Committee Report." The Entertainment Committee has completed plans for several excursions to points of interest in the city.

The Sixth National Exposition of Chemical Industries will be held at the Grand Central Palace, New York City, Sept. 20-25. The exposition has been divided into sections. A fuel economy division and a materials handling division have been added. Five symposiums divided into the following classifications will be read during the week: Fuel Economy, Materials Handling, Industrial Management, Chemical Engineering, and a symposium on Ceramics. The Fuel Economy Symposium will include "Burning Coal at 100 per cent B.t.u. Efficiency," W. O. Rankin, Quigley Furnace Specialties Co.; "Saving Fuel by Controlling Chimney Losses," F. F. Uehling, Uehling Instrument Co.; "Fluid Heat Transmission," Alexander B. McKechnie, Parks-Cramer Co.; "Producer Gas and the Modern Mechanical Producer," W. B. Chapman, Chapman Engineering Co.; "Refractory Cement; Life Insurance for a Furnace," F. W. Reisman, Quigley Furnace Specialties Co.; "Preventing Conduction and Radiation Heat Waste," S. L. Barnes, Armstrong Cork Co.; and "The Reason for the Fuel Saving in the Dressler Kiln," Conrad Dressler, American Dressler Tunnel Kilns, Inc.

Miscellaneous News

The Kerchoff Power Plant of the San Joaquin Light and Power Corporation, built at a cost of approximately $5,500,000, with a maximum output of plant amounting to 50,000 hp., was started Aug. 15 with elaborate ceremonies in which the electrical men of the state and the general public took part. The plant is situated on the San Joaquin River, near Auberry, about thirty miles from Fresno.

An Order Curtailing the Consumption of electric power to all Northern and Central California industries by 20 per cent was issued by H. G. Butler, State Power Administrator, on Aug. 19, following a hearing of power consumers and distributors. All cities and towns will be asked to reduce street lighting and curtail the use of electric signs. Administrator Butler gave the average weekly generation for three months at 5,600,000 kw., of which steam plants generated 2,700,000 kw.

The San Joaquin Light and Power Co. of California doubled its power with the opening on Aug. 22 of a new hydro-electric plant on the main fork of the San Joaquin River. The new plant will have a capacity of 44,000 hp., bringing the company's total power capacity to 85,500 hp. The company already had six hydro-electric plants, but their combined horsepower was only 24,000. Their other units are a steam turbine plant at Bakersfield, which has a capacity of 18,000 hp., and two steam reserve plants at Fresno and Betteravia, with a capacity of 3,500 hp.

Airplane in Power Plant Construction—What is believed to be the first use of an airplane by an individual for business purposes is announced by the San Joaquin Light and Power Co. of California. Rex C. Starr, construction engineer of the various projects now under way, has purchased a machine and engaged an aviator. The machine will be used in making flights to Huntington Lake, Auberry, Crane Valley and Kings River. Many of these places are accessible only over long mountain roads. In an airplane these projects can all be visited on the same day.

Caribou Power Project—An order issued by the Railroad Commission Aug. 19 authorizes the Great Western Power Co. of California to float a bond issue of $3,500,000. The proceeds will be used to defray the cost of completing the Caribou power development on the Feather River and the transmission line from the Caribou plant to Valona, Contra Costa County. It was originally estimated that the cost of the Caribou plant and the transmission line would total $6,057,430. Today it is estimated that the total will reach $10,674,897.66. According to the evidence submitted with the application, the increase is due to enlarging the tunnels so as to permit of the construction of an 80,000-kw. plant instead of a 60,000-kw. plant as originally planned and to unforeseen difficulties experienced in tunnel construction. Increases in cost of materials and supplies, increases in wages and difficulty in keeping employees permanently engaged on the construction work are also given as reasons for the additional cost.

Business Items

The Mesta Machine Company has opened an office in the Singer Building, New York, from which point all its foreign business will be handled. The New York office will also be the sales office for the New York and Eastern States territory. M. M. Moore will be in charge.

The Burke Electric Co. announces the appointment of L. L. Myers as general Western sales manager. Mr. Myers' headquarters will continue to be in the Illuminating Building, Cleveland, Ohio, where he has been the Burke Electric Co.'s sales representative for the Cleveland territory for several years. **L. B. Ritchie** has been appointed General Eastern Sales Manager, with headquarters at 30 Church Street, New York City, where he has for some time been sales representative for the New York territory of the Burke Electric Co.

Trade Catalogs

"Insulating Compounds" is the title of a new bulletin by the General Electric Co. The booklet is designed to assist the purchaser in the selection of proper insulating compounds. Various materials handled by the company are described and photographic illustrations of machinery used in the manufacture of these products are shown.

"Permutit Water Rectification Systems" is the title of a new 30-page catalog published by The Permutit Co., New York City. Brief descriptions accompanied by illustrations are given of the various apparatus handled by the company including water-softening systems, filters, salt tanks, etc. A copy of the booklet will be sent on request.

The General Electric Co. has ready for distribution Bulletin No. 41,311 entitled "Synchronous Condensers." The text covers power-factor correction and power-factor control through synchronous condensers. Particularly interesting sections of the bulletin are the data on power factor, causes and effects of low power factor and the application of the synchronous condenser, with several calculations of such installations for both power-factor correction and control.

The Sprague Electric Works of the General Electric Co., New York, has issued a 70-page booklet entitled, "The Universal Key." The booklet contains illustrations and descriptions of the complete line of conduit boxes and covers handled by this company. It is compiled in such a manner that it furnishes a quick reference for matching any standard wiring device to any desired box and cover. A copy will be sent on request.

The Locomotive Superheater Co., of New York, has published a Data Book for Engineers. The object of the book, which is of handy pocket size, is to assist stationary engineers in their every-day work by furnishing them with useful data such as they have occasion to use frequently. The material for the book has been gathered from various authoritative sources and should prove of value to engineers. A copy will be sent to anyone interested upon request.

"Pelton Impulse and Reaction Turbine Installations" is the title of a new 48-page catalog published by the Pelton Water Wheel Co., of New York. This booklet is designd to show the scope and activities of the Pelton Company in the hydro-electric fild. A number of illustrations show Pelton units operating under varying conditions of head, volume and capacity. They embrace horizontal and vertical turbines of both reaction and impulse types, used in large generating stations, automatic and remote-control plants and in exciter sets.

The General Electric Co. has ready for distribution bulletin No. 48,715 entitled "Insulating Fabrics." This booklet deals entirely with various classes of insulating materials put on the market by the company. It is an illustrated bulletin, the photographs telling the story in outline, of how such fabrics are produced. Views are shown of baking ovens used in producing varnished fabrics, the process of insulating field coils with varnished fabric tape, the taping and wrapping of armature coils with varnished fabric. A list of standard materials is given, designed to assist customers in making a selection. A copy will be sent on request.

New Construction

PROPOSED WORK

Me., Deering (Portland P. O.)—St. Joseph's Convent had plans prepared for a convent to include a dormitory, chapel, autorium, etc., here. A steam heating system will be installed. About $300,000. O'Connell, Show, 18 Boylston St., Boston, Mass., Archts.

Me., Lewiston—The Androscoggin Mills will soon award the contract for about one hundred 1 story two-family houses for workmen, including steam heating systems. About $1,000,000.

Me., Skowhegan — The Central Maine Power Co., 40 Water St., Augusta, plans to build a hydro-electric plant. About $1,350,000. Frank H. Mason, Chief Engr. J. A. Leonard, Resident Engr.

Mass., Norwood—J. W. Beal, Archt., 62 Sumner St., Boston, will soon award the contract for a 2 story, 136 x 280 ft. textile mill including a steam heating system for the Holliston Mills, Lennox Ave. Plans include a 1 story, 50 x 70 ft. boiler house. About $300,000.

Mass., Tyngsboro—D. Sheehan is in the market for an 11 x 15 ft. Erie engine.

Mass., Wakefield—Heywood Bros. and the Wakefield Co. will soon award the contract for a factory including two 205 hp. Heine boilers. C. A. Van Derveer, Genl. Mgr. Noted Jan. 6.

Conn., Montville—Robert Gair, 50 Washington St., Brooklyn, N. Y., is having plans prepared for several houses including a steam heating system. About $250,000. Lockwood Green, 101 Park Ave., New York City, Engrs.

N. Y., Long Island City—The Bd. Educ., 500 Park Ave., New York City, plans to build a school on Grand and 6th Aves. to cost about $900,000 and a school on Wool and Laconia Sts. to cost about $500,000. A steam heating system will be installed in each. C. B. J. Snyder, Municipal Bldg., Archt. and Engr.

N. Y., Richmond Hill, L. I.—The Bd. Educ., 500 Park Ave., New York City, plans to build a high school addition including a steam heating system on Cedar Ave. About $500,000. C. B. J. Snyder, Municipal Bldg., New York City, Archt. and Engr.

N. Y., Richmond Hill, L. I.—The Bd. Educ., 500 Park Ave., New York City, plans to build a school including a steam heating system on Hillside Ave. About $900,000. C. B. Snyder, Municipal Bldg., New York City, Engr.

N. Y., Syracuse—The Bd. of Mgrs. of Onondaga Co. received bids for the installation of heating systems in the proposed children's and adults' pavilions at the Onondaga Tuberculosis Sanatorium from Ed. Joy, 133 Market St., $25,373 and $12,778; Ed. Bates, 228 West Water St., $23,404, $9,550; W. B. Goldie, 274 James St., $20,174, $10,314.

N. J., Woodlynne (Camden P. O.)—The Camden Ice Co., c/o Benj. Howell Lackey, Archt., 509 Federal St., Camden, is having plans prepared for an ice plant and coal yards here. A steam heating system will be installed in same.

Va., Ashland—The Henry Clay Inn Co. is in the market for a hot water heating plant, deep well pump and gasoline engine. S. Hatcher, Purch. Agt.

Va., Richmond—C. H. Bruner, 715 West Broad St., is in the market for an air compressor.

Va., Richmond—The Verra Hat Works, 211 North 1st St., is in the market for boiler injectors and air compressors.

Va., South Richmond (Richmond P. O.)—R. H. Richardson, 1310 Hull St., is in the market for an air compressor.

La., New Orleans—J. A. Wetmore, Supervising Archt., Treasury Dept., Wash., D. C., will receive bids until September 23 for the installation of a refrigerating machine at the Post Office and Court House here.

La., New Orleans — Emil Weil, Archt., Whitney Block, will receive bids until September 27 for a 4 story addition including a steam heating system for the Touro Infirmary.

O., Cleveland—Jacob Babin, Hotel Olmstead, has purchased a site and plans to build an 8 story, 50 x 190 ft. commercial building including a steam heating system on Euclid Ave. between East 30th and East 40th Sts. About $600,000.

O., Cleveland—The Glidden Co., Madison Ave., plans to build an 8 story commercial building including a steam heating system on Euclid Ave. and East 55th St. About $500,000. A. D. Joyce, Pres.

O., Cleveland — The Babies Dispensary and Hospital, 2500 East 35th St., had plans prepared for an 8 story, 60 x 150 ft. children's hospital including a power plant at 11020 Euclid Ave. About $500,000. Abram Garfield, Natl. City Bldg., Archt.

O., Cleveland—The B. F. Keith Theater Co., 1564 B'way., plans to build a theater and office building including steam heating system. About $1,000,000. Rapp & Rapp, 190 North State St., Chicago, Ill., Archts.

O., Cleveland—The Natl. Lamp Co. of the General Electric Co., Nela Park, East Cleveland, plans to build a 3 story factory including a steam heating system on Alonzo Ave. near Aetna Rd. G. H. Johnson, Nela Park, Archt. and Engr. About $300,000.

O., Cleveland—William Yamshone, 9905 Ostend Ave., is having plans prepared for a 3 story, 120 x 200 ft. commercial theater building including a steam heating system at East 141st St. and St. Clair Ave. About $250,000.

O., Elyria — The Reliance Crane Co. is having plans prepared for a 1 story, 118 x 188 ft. factory and power house. About $125,000. Watson Eng. Co., Hippodrome Bldg., Cleveland, Engrs.

O., Lakewood (Cleveland P. O.)—The Bd. Educ., 1456 Warren Rd., received bid for steam heating system in the proposed addition to school at Clifton Blvd. and Summit Ave. from Price & Weller, 707 Canal Rd., Cleveland, at $16,584.

O., Lorain—The Bd. Educ. received bids for a 1 story grade school on 4th St. and Hamilton Ave. from Chas. Peterson & Co., 4500 Euclid Ave., Cleveland, at $214,000 and Geo. Kratt, Lorain, at $218,522; for steam heating system from Chappel-Warren Co., St. Clair Ave., Cleveland, at $60,000. Noted Feb. 3.

Mich., Detroit—The City Plan Comn. engaged Smith, Hinchman & Grylls, Archts., 710 Washington Arcade, to prepare preliminary plans for a 6 story city hall including a steam heating system on Woodward Ave. About $3,000,000.

Ill., Chicago—E. E. Roberts, Archt., 105 North Clark St., will soon receive bids for a 3 story, 115 x 210 ft. milk bottling plant including a steam heating and refrigeration system on Claybourne Ave. and Division St. for the Borden Farm Products Co., 136 West Lake St. About $250,000.

Wis., Janesville—The city will receive bids until October 1 for furnishing an 8,000,000 gal. horizontal cross compound crank and fly wheel pumping engine. C. V. Kerch, City Hall, Engr.

Wis., Manitowoc — The Jacquet Motor Corp. is having plans prepared for a 3 story, 150 x 300 ft. trunk factory on Main St. Motors, etc., will be installed in same. About $75,000. Alfred Jackson, Mgr. H. B. Kamschulte, Archt. and Engr.

Wis., Marshfield—The city received low bids for boilers from the Wickes Boiler Co., Saginaw, Mich., $19,868 and $22,225; for superheaters from the Dravo Co., 1195 30th St., Milwaukee, $3,320 and $3,950; for F. W. Heaters from the Warren Webster Co., 53 West Jackson Blvd., $2,750.

Wis., Merton—The Merton Dairy Products Co., will receive bids about September 11 for a 3 story, 60 x 145 ft. factory on Main St. Motors, etc. will be installed in same. About $40,000. M. Tullgren & Sons, Wisconsin Natl. Bank Bldg., Milwaukee, Archts.

Wis., Milwaukee—The Sewerage Comn. is having plans prepared for a power house including equipment, $250,000, sewage tanks and equipment, $2,175,000, boilers, piping and equipment, $500,000, etc.

Wis., Wauwatosa—The Bd. of Administration plans to build a 1 story central heating plant including equipment. About $300,000.

Ia., Wapello—F. G. Wright, Co. Aud., will receive bids until September 22 for a drainage pumping plant including 2 centrifugal pumps of equal capacity driven by oil engines, etc. About $30,000.

Minn., Chisholm—The city clk. will receive bids until October 15 for a 2 story, 195 x 300 ft. municipal building, including a steam heating system. About $650,000. Anthony Puck, Torrey Bldg., Duluth, Archt. and Engr.

Kan., Topeka—The Security Benefit Association is having plans prepared for a hospital and detention building including a small garage and power house. About $300,000. Schmidt, Garden & Martin, 104 South Michigan Ave., Chicago, Archts.

N. D., Devils Lake—The Farmers' Cold Storage Co. plans to build a creamery and cold storage building. About $100,000. Thomas Malony, Pres.

Mont., Miles City—The Yellowstone Irrigation Co. is promoting a power and irrigation project. About $500,000.

Mo., St. Louis—The city will receive bids until September 21 for an addition to the boiler room at the Koch Hospital. Noted August 10.

Ark., Judsonia — The Arkansas Hydro-Electric Development Co., Little Rock, plans to build the first unit of a hydro-electric plant on Little Red River about 18 miles from here including 10,500 hp. power plant and dam. About $1,208,000. J. E. Sirrine, Greenville, S. C., Consult. Engr.; Dickinson & Watkins, Little Rock, Resident Engrs.

Ore., Bandon—The city has applied to the state engineer for permission to divert 25 sec.-ft. water from Wilson Creek for power purposes. Plans include a 1,000 kw. power plant.

Cal., Honcut—The Irrigation Bd. plans to build a canal and irrigation reservoir system in the Honcut-Yuba Irrigation Dist. The project includes gravity and pumping diversion at separate points. About $1,780,-636. V. P. McCray and F. T. McCray, Engrs.

Cal., Sacramento—M. J. Desmond, City Clk., will soon award the contract for furnishing transformers, sluice gates, centrifugal pumps, induction motors, intake conduits, pumping station, power manhole, etc., for the proposed pumping and filtration works.

N. S., Windsor — T. B. Akins, Windsor, and Wright & Jodrey, Wolfville, are interested in a company which is having plans prepared for a dam, power house, pulp mill, etc. About $250,000.

Que., Three Rivers—Mr. Lambert, City Engr., is in the market for one 100 hp. 62 cycle, 2,200 volt, 900 rev., 75 amp. electric synchronous motor.

Ont., Fenelon Falls—Oliver Smith, Engr., Lindsay, is having plans prepared for a new water works system including a pumphouse and the installation of electrically operated centrifugal pumps. About $50,000.

Ont., Kapuskasing—The Spruce Falls Co. plans to develop the water power here.

Ont., Richmond Hill — The Loyal True Blue & Orange Home, County Orange Bldg., Richmond St., Toronto, plans to build a 3 story children's home including a steam heating system on Yonge St. About $300,-000.

Mexico, Villa Acuna, Coahuila — The Mexican Government has granted a concession to Antonio Guijosa for an electric light and power plant here.

CONTRACTS AWARDED

Mass., Boston—The Tremont Trust Co., 14 State St., has awarded the contract for a 12 story, 100 x 130 ft. bank and office building on Court St. to J. H. Broderick, 101 Tremont St. A steam heating system will be installed in same. About $2,300,000.

Mass., Fall River—The New England Oil Corp. has awarded the contract for an oil storage building, pumping station, etc., to the Unit Constr. Co., 299 Madison Ave., New York City. About $5,000,000.

R. I., Bellefonte—The Imperial Printing & Finishing Co. has awarded the contract for a 1 story, 27 x 135 ft. generator building to the C. I. Bigney Constr. Co., 357 Westminster St., Providence. About $25,-000.

N. Y., New York—The Herald Sq. Printing Co., care of H. C. Volz, Archt. and Engr., 373 Fulton St., Brooklyn, will construct an 8 story loft building, including a steam heating system. Work will be done by day labor.

N. Y., Yonkers — The Yonkers Electric Light & Power Co. has awarded the contract for a 1 story sub-station, to William Young & Co., 414 West 41st St., New York City, at $75,000.

Pa., New Castle — The Bd. Educ. has awarded the contract for a 3 story, 240 x 340 ft. high school to Moore & Lamb, 202 Stambaugh St., Youngstown, O., at $340,-825. A steam heating system will be installed in same.

D. C., Washington — The Dist. Comrs. have awarded the contract for the installation of a heating and ventilating system in the Petworth School and addition, to the Federal Heating Co., 310 13th St. N. W., at $33,938.

Va., Danville — The Riverside & Dan River Cotton Mills has awarded the contract for a power house to the Aberthaw Constr. Co., 27 School St., Boston, Mass. About $100,000.

O., Cleveland—The city has awarded contracts as follows: turbo-generator, Allis-Chalmers Mfg. Co., 1121 Schofield Bldg., $188,000; switchboard, Westinghouse Mfg. Co., 6905 Susquehanna St., Pittsburgh, Pa., $12,707; condenser and auxiliaries, Wheeler Condenser Co., Indianapolis, Ind., $65,000. Noted Aug. 17.

Mich., Detroit—The Bd. Educ., 50 B'way. has awarded the contract for heating ventilating and plumbing systems in the Cooper school, to J. W. Partlan, 51 Park Pl., at $93,800; in th Leland school addition, Custer school and Crossman school addition, to the Drake Avery Co., 40 State St., at $91,-915, $92,212, $51,821; and in the Carstens school, to W. J. Rewoldt, 506 Owen Bldg., at $62,108. Noted Sept. 7.

Mich., Kalamazoo — The Bd. Educ. has awarded the contract for a 3 story, 140 x 363 ft. school, to the Vanderhorst Co. at $554,512. A steam heating system will be installed in same.

Ill., East St. Louis — The Eagle-Picher Lead Co., Ry. Exch. Bldg., St. Louis, Mo., has awarded the contract for a factory here including power plant, boiler room, machine shop, etc., to the Wimmer Contg. Co., Victoria Bldg., St. Louis, Mo. About $600,000.

Wis., Sheboygan—The H. J. Holman Co., 1716 Calumet Drive, has awarded the contract for a 2 story, 60 x 120 ft. overall factory to J. Hammes, 1409 Lincoln St., at $6,000, and is in the market for motors, etc.

Wis., Sheboygan — The Sheboygan Cigar Box Lumber & Mfg. Co. has awarded the contract for a 3 story 60 x 85 ft. cigar box factory and remodeling present power house, installing new boilers, etc., to J. Hildebrand, 907 North 4th St. About $10,000.

N. D., Grand Forks — The Industrial Comn. of North Dakota, has awarded the contract for the installation of 17 motors of various sizes in the new terminal mill and elevator here, to the General Electric Co., 410 3rd Ave., North Minneapolis, Minn. Noted Aug. 30.

Mo., St. Louis — The Bd. Educ. has awarded the contracts for 4 schools here, to the Murch Bros. Constr. Co., Exchange Bldg., $328,930; E. C. Gerhard Bldg. Co., Post-Dispatch Bldg., $280,268; Kellerman Constr. Co., Victoria Bldg., $298,458 and $437,799. A low pressure steam heating and forced ventilation system will be installed in each.

Mo., St. Louis—The Bridge & Beach Mfg. Co., 503 South 1st St., has awarded the contract for 17 buildings including a power plant, etc., on Union and Brown Aves., to the Fruin-Colnan Contg. Co., Merchant's Laclede Bldg., at $800,000.

Tex., Austin—The State Bd. of Control has awarded the contract for the installation of a heating plant in the Confederate Home here, to Kirkwood & Wharton, San Antonio, at $20,316.

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